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DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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AFIT/GOR/ENS/88D-23

RESPONSE SURFACE METHODOLOGY
APPLIED TO THE RADAR
RANGE EQUATION

THESIS

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THESIS

Presented to the Faculty of the School of Engineering

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Operations Research

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December 1988

Preface

The purpose of this thesis was to analyze certain aspects of the Electronic Warfare Reprogramming Database. It was designed to use stochastic methods and statistical analysis to ascertain the degree of confidence and margin of error in the database. The questions posed by the Air Force Electronic Warfare Center at Kelly Air Force Base were answered and an extensive analysis of the radar range calculations was accomplished.

I am very much in debt to Dr. Krile for his invaluable assistance in my radar principles tutorial. His patience and understanding were greatly appreciated. Thanks must also be sent to Major Bauer for his never-ending optimistic attitude and constant "pep talks".

Wesley D. True Jr.

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List of Acronyms

Acronyms

A_e	- Effective Antenna Aperture
AFEWC	- Air Force Electronic Warfare Center
AFIT	- Air Force Institute of Technology
ANOVA	- Analysis of Variance
B	- Bandwidth
CSC	- Classroom Support Computer
CW	- Continuous Wave Radar
dB	- Decibels
EWIR	- Electronic Warfare Integrated Reprogramming Database
F	- Frequency
f_d	- Doppler Frequency
f_{if}	- Intermediate Frequency
f_o	- Outgoing Frequency
F_s	- Standard System Noise Figure
G	- Antenna Gain
GT	- Gain of Transmitting Antenna
GR	- Gain of Receiving Antenna
Hz	- Hertz
IRE	- Institute of Radio Engineers
k	- Boltzman's Constant
K	- Temperature in Kelvin
L	- System Losses
λ	- Wavelength
msec	- milliseconds
N	- Number of Pulses Incoherently Integrated
NAS	- Naval Air Station
NF	- Noise Figure
NRL	- Naval Research Laboratory
P	- Power
PD	- Probability of Detection
PFA	- Probability of False Alarm
P_n	- Thermal Noise Power
P_r	- Re-radiated Power
PRF	- Pulse Repetition Frequency
P_t	- Peak Transmitted Power
R	- Range
r	- Resistance
RCS	- Radar Cross Section
S	- Signal
S/N	- Signal-to-Noise Ratio
SAS	- Statistical Analysis System
sec	- Seconds
σ	- Radar Cross Section
T	- Absolute Temperature, Effective Input Temperature
t_0	- Integration Time

T_o	- Standard Reference Temperature, 290° K
T_s	- Effective System Noise Temperature
V	- Volts
xi	- Reactance
z	- Antenna Impedance

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Abstract

The purpose of this thesis is to analyze the Electronic Warfare Integrated Reprogramming (EWIR) database elements. The integration time for continuous wave radars is illustrated. The effects of the confidence factors on data within the database is analyzed. These confidence factors affect certain parameters more than others and they also affect the radar range. Response surface methodology is used to identify the significant effects on the radar range equation, using EWIR database parameters. Linear equations are created for several radars and are compared to the actual ranges.

RESPONSE SURFACE METHODOLOGY APPLIED TO THE RADAR RANGE EQUATION

I. Introduction

The Air Force Electronic Warfare Center (AFEWC) directorate for Electronic Security Command is concerned about the elements in the Electronic Warfare Integrated Reprogramming (EWIR) database. The EWIR database contains information contributed by several U.S. Government intelligence agencies on the operating characteristics of electronic intelligence emitters of both free world and Warsaw Pact armed forces. The AFEWC would like an independent assessment of the database parameters concerned with radar range.

Justification

The AFEWC requested an independent assessment of the database elements concerned with radar range using stochastic processes.

Research Question

What are the significant effects that determine radar range using EWIR database parameters?

Subsidiary Questions

The AFEWC requested the following questions be answered to assist in the research of the main problem. These are as follows:

1. Is there a decision point in a generic Continuous Wave (CW) radar for which a minimum Signal-to-Noise (S/N) ratio is meaningful?

2. If so, are all CW functions disabled when the minimum S/N ratio is not attained?

3. Stochastic theory applies for discrete systems such as pulsed radar. Can it be applied to CW systems as well?

4. As the Pulse Repetition Frequency (PRF) of a pulsed radar increases, (if the pulse width is not decreased) the duty cycle approaches 1.00. The duty cycle of a CW radar is 1.00. Can we assume from this that discontinuities do not exist in the transition from a discrete function (pulsed radar) to a continuous function (CW radar)?

5. If it is shown that a stochastic description of a minimum S/N ratio for CW radar is undefined, is there a non-stochastic definition that is verifiable and generic?

Scope

This thesis will use EWIR database parameters, and the confidence factors associated with each, in order to analyze the sensitivities of these confidence factors on the radar range. Once this study has examined the sensitivities of the main effects on the range, conclusions will be drawn on the overall effect of the confidence factors.

Standards

An R-squared value of 99% will be the minimum standard used for an adequate fit of the model to the data. The R-squared value is the ratio of the sum-of-squares of regression over the sum-of-squares of the total design. This is shown graphically in three-dimensional space below:

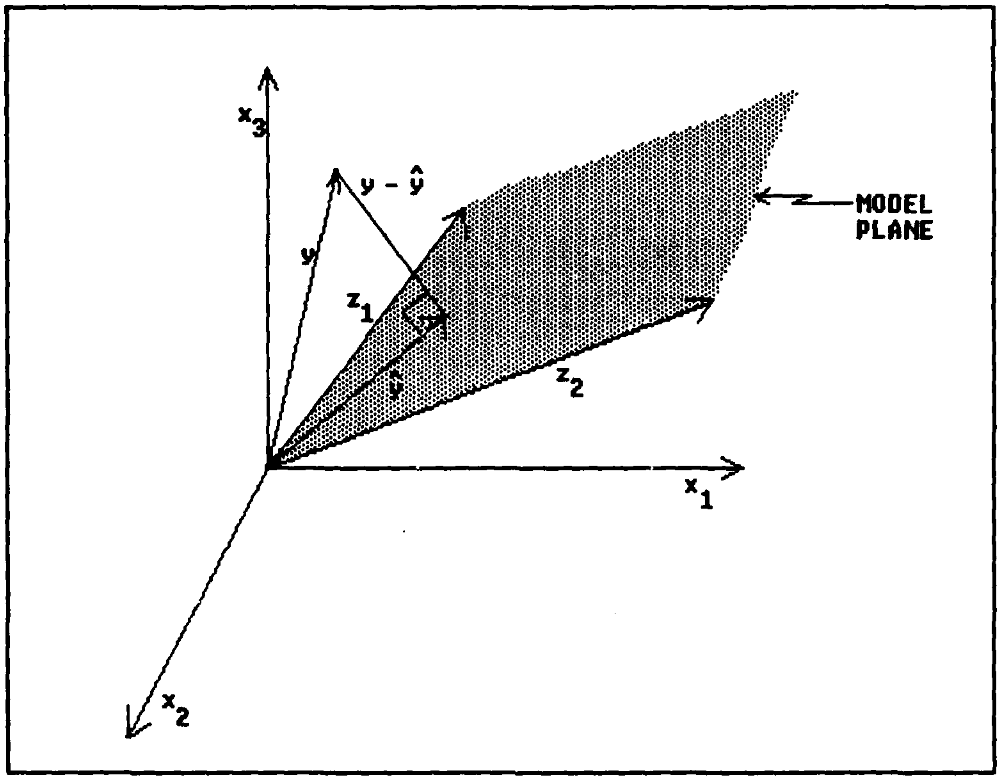


FIGURE 1. GEOMETRIC INTERPRETATION OF THE SUM OF SQUARES

The y in the figure above is the equation of the actual data and the $\hat{y}$ is the estimated equation. The squared length of y is the sum-of-squares of the total data and the squared length of $y-\hat{y}$ is the sum-of-squares of regression. This ratio provides a good estimate if the residual plots reveal no dependent tendency. The R-squared value gives the experimental designer an estimation of how "close" y is to $\hat{y}$ and thus a criteria to determine the adequacy of fit of the linear equation to the data.

Methodology

Five radars will be chosen from the EWIR database. The variables needed to calculate their ranges will be extracted from the database. The method of response surface methodology will be employed on this data to determine the significant effects on the range of the radars chosen. Once the significant effects of the complete model have

been identified, a reduced model for each radar will be created using an R-squared value of 99%.

Methods and Equipment

The EWIR database will be the source of the radar data. The Statistical Analysis System (SAS) package on the Classroom Support Computer (CSC) on the Air Force Institute of Technology (AFIT) computer system will be used for the response surface methodology analysis. The computer languages Fortran and Basic will be used to calculate range and integration times respectively.

II. Literature Search

The Origin of Radar

"The name 'radar' was coined from the words RAdio Detection And Ranging by two U.S. Naval officers, F.R. Furth and S.M. Tucker." (12:15)

Radar's method of detection works by "bouncing" radio waves from objects and "listening" for their returned echo.

> ...radar is a radio device for "seeing" remote objects, using radio waves instead of light waves, and when it "sees" an object, it indicates its position with uncanny accuracy. Radar does this by sending out, in a known direction, very short but powerful pulses of radio frequency energy spaced widely apart and receiving the weak pulses reflected back from objects or "targets" which the pulses have illuminated. The time required for the radio energy, or signal, to travel out to the target and back is measured, and the distance is indicated by the time of travel, since the greater the distance to the target, the greater the time required for the signal to get to the target and back again. (12:15)

The origin of radar is not as clear as one would hope.

> When radar finally was made public property, those who started it had become more interested in developing other new things than in contending for the purification of history. As a result, the true origin of radar has become obscured in conflicting claims and "tales not-quite-agreed-upon". (12:14)

Page states that radar was discovered in steps, and the first step took place in

> ... a little shack on the east side of the Anacosta River in Washington, D.C., known as the Aircraft Radio Laboratory, Anacosta Naval Air Station, and on a truck on the west side of the river near Hains Point. With a high frequency radio transmitter in the shack, and a radio receiver in the truck, A.H. Taylor and L.C. Young were studying high frequency radio communication. When they had obtained a steady tone they wanted, they heard the tone unexpectedly swell to nearly double its normal loudness, then die away to almost nothing. [Due to a refraction and phase reversal of the radio waves.] This quite unexpected occurrence was observed to coincide with the passage of a river steamer across the line of sight between the transmitter and the receiver. (12:19)

Taylor and Young were employed by the U.S. Navy and knew that one of the Navy's problems was to prevent enemy ships from penetrating harbors and fleet formations under cover of darkness. They also noticed how easily the river steamer was

> ...detected by radio, they proposed that radio be used in "burglar alarm" fashion across harbor entrances, and between ships operating in pairs, with the transmitter on one ship and the receiver on another, to detect the passage of any ship between the two at night or in fog. The proposal was made officially in a letter from the Commanding Officer, NAS, Anacosta, to the Navy Bureau of Engineering, dated September 27, 1922. (12:19)

Skolnik reports that this was a continuous-wave wave-interference radar and that it detected a wooden ship. (14:9)

> In 1925, "...Dr. G. Breit and M.A. Tuve of the Department of Terrestrial Magnetism Carnegie Institution of Washington, proposed the use of radio pulses for measuring the height of the ionosphere..." (12:29-31)

In 1930 the first detection of aircraft occurred

> ...when the same Mr. Young and Mr. L.A. Hyland at the U.S. Naval Research Laboratory, successor to the Aircraft Radio Laboratory, were experimenting with short-wave direction finding. A short-wave transmitter emitting a steady tone from the main Laboratory was being received by a short-wave receiver several miles away. The receiver was using a special directive antenna that had a very narrow "blind spot" in one direction. The antenna was rotated to point the blind spot toward the transmitter so that the tone could scarcely be heard, thus indicating the direction to the transmitter. In the operation the tone mysteriously got loud and fluctuated violently. Hyland examined the receiver trying to locate the source of the problem. In exasperation Hyland was about to return to the Laboratory with his "balky" receiver when he observed a significant fact: every time the tone "danced" there was an airplane flying overhead. Realizing the importance of this "discovery" that an airplane can be detected by radio, he immediately returned to the Laboratory and wrote a memorandum describing his experience. This also was reported in a letter from the Director, NRL, to the chief, Bureau of Engineering, dated November 5, 1930.
>
> After this memorandum, two ideas quickly followed; one was that a radio apparatus be developed for detecting aircraft, and second that a pulse method be used due to its long range.
>
> In 1930 the idea of pulsed radar was not quickly accepted due to the fact that requirements for radar at the time were much greater than the existing technology could overcome. But Dr. Taylor worked with the NRL on this problem for three and a half years and the ideas and usefulness of radio detection started fading away due to the fact there was no need and the existing technology. Then in late 1933 or early 1934 (prior to March 14) at NRL, Leo C. Young proposed it to his superior, Dr. A. Hoyt Taylor, and persuaded Taylor to authorize work in the Laboratory. (12:25-26)

Skolnik relates that by 1932 the equipment detected aircraft at distances as great as 50 miles from the transmitter.

> The NRL work on aircraft detection with CW wave interference was kept classified until 1933, when several Bell Telephone Laboratories engineers reported detection of aircraft during the course of their experiments. The NRL work was disclosed in a patent filed and granted to Taylor, Young, and Hyland on a "System for Detecting Objects by Radio". (14:9)

All the experiments conducted thus far were CW type radars and the first attempt at a pulsed radar was not until December, 1934. This first attempt was a failure and it was not a success until April 28, 1936. The British demonstrated the successful application of the pulse technique in June, 1935.

In England, in February of 1935, Robert Watson-Watt submitted a memorandum to the Committee for the Scientific Survey of Air Defense. In an article by G.R.M. Garratt, this memorandum is referred to as the "Birth Certificate" of radar. (7:141) This can hardly be considered a birth certificate considering the "child" was already one-year-old in the United States.

In Germany, during the fall of 1934, a group in the firm of GEMA proposed radar to the Chief Air Marshall Herman Goering. The idea was "...first turned down as impractical, then rejected as being purely a home defense device; the German war plan indicated no need for home defense! Only later, when radar's value for offense became apparent, did Hitler permit its development for the direction of gunfire." (12:36)

Skolnik states that the "...development of radar as a full-fledged technology did not occur until World War II, the basic principle of radar detection is almost as old as the subject of electromagnetism itself." (14:8) He then discusses Heinrich Hertz's experiments with Maxwell's theories in 1886, Hulsmeyer's experiments in 1903, and Marconi's experiments in 1922. All of these did not develop into what is known as a radar apparatus.

In contrast, Page proposes that the discovery of radar was by Mr. Young on March 14, 1934. He bases his statement on the fact that the "...ideas to basic radar were all contained in the apparatus Mr. Young designed." (12:37-39) He states there were others but they did not contain these ideas of a basic radar or that no radars resulted from these experiments.

Skolnik proposes that "...radar developed independently and simultaneously in several countries just prior to World War II. It is not possible to single out any one individual as the inventor; there were many fathers of radar." (14:12)

The Radar Range Equation

The radar range equation was first derived and used during World War II. It was first printed in a classified report by Norton and Omberg in 1943, and later declassified and presented at an Institute of Radio Engineers (IRE) meeting in early 1946. (1:vii) Many authors show the derivation of the radar range equation, and a majority of them refer to the derivation by Bussgang in 1959 as the "standard". Blake states that "With minor variations, [to Blake's equation, Bussgang's equation] is often presented in books and papers as 'the radar range equation' ". (2:17) Bussgang developed a unified method for computing radar range for several types of radars. (1:39) His method uses a normalized range for the detection of steady targets by coherent radars. (1:vii)

Hall uses a radar range equation that compares different type of radars by their ratio of noise power to their received energy. (1:71)

The EWIR database uses Blake's method of calculating the maximum detection range of a radar set. The basic difference between Bussgang's equation and Blake's is that Blake's 1) adds a pattern propagation factor; 2) adds different definition of the loss factor; 3) does not assume that the gain of the receiving antenna is equal to the gain of the transmitting antenna; 4) combines the noise figure and the standard temperature. (2:17)

The differences can be resolved by including the propagation factor in the gains and losses of Bussgang's formula; assume a different definition of losses; separate the gain factor into two gains; and equate the system noise figure with Bussgang's noise figure and standard temperature.

A recent article by Perez and Gardiol describes how to use a calculator to solve the radar equation problem, but they do not use a noise figure or a variable for losses, or a propagation factor but use a variable called the noise temperature. (13:98)

The equation that will be used in this thesis is Bussgang's (with two minor variations) since it is commonly referred to as "the radar range equation".

Since these derivations, there have been many types of refinements and additions to account for other factors in the calculation of a radar, however Skolnik cautions:

> ...the quality of the prediction is a function of the amount of effort employed in determining the quantitative effects of the various parameters. Unfortunately, the effort required to specify completely the effects of all radar parameters to the degree of accuracy required for range prediction is usually not economically justified. A compromise is always necessary between what one would like to have and what one can actually get with reasonable effort. (14:16)

This is why Bussgang's equation and the technique of response surface methodology were chosen in this thesis because of how well suited they are to this type of application.

III. Background

Block Diagram

A diagram of a simple CW radar was reproduced from Skolnik's book, An Introduction to Radar Systems, (14:75) and is shown below in Figure 2.

The CW transmitter emits an outgoing frequency, f_o, that is transmitted and sent to the mixer. The mixer combines the outgoing signal, f_o, with an intermediate frequency, f_{if}. The mixed signal comes from the mixer to a sideband filter which filters out every signal except the signal at f_o plus the intermediate frequency.

The receiving mixer takes the received signal ($f_o \pm f_d$) and mixes it with the combined signal from the sideband filter ($f_o + f_{if}$). The receiver mixer sends the signal at $f_{if} \pm f_d$ to the intermediate frequency amplifier. The IF amplifier amplifies the signal and passes it to the second detector. The second detector mixes the f_{if} to the video range so that only a signal at the Doppler frequency remains, which then can be sent to the Doppler amplifier. The Doppler amplifier boosts the amplitude, then passes the signal to the indicator or radar scope.

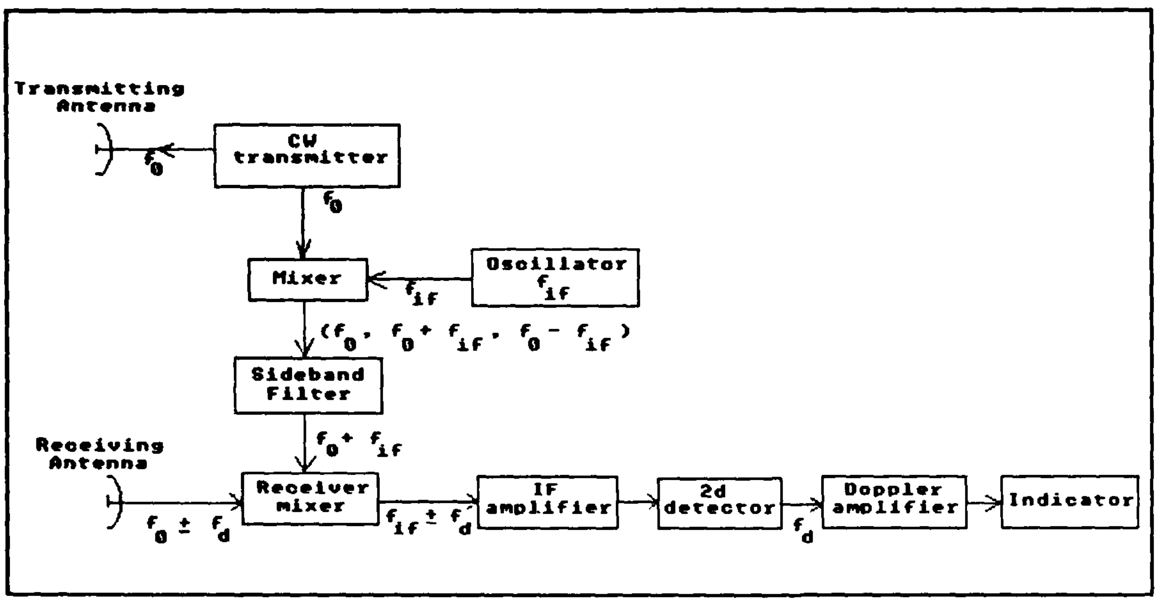


FIGURE 2. BLOCK DIAGRAM OF A CW DOPPLER RADAR

Equation Derivations

The first equation that will be derived will be the signal-to-noise ratio equation, then the range equation will be derived. An abundance of credit must be given to Dr. Krile for his assistance in guiding my education with these equations. (9:13-14)

Signal-to-Noise Ratio. The peak transmitted power (P_t) measured at the flange of the transmitter is defined as being equal to volts (V), (root mean squared) squared or simply the mean squared voltage divided by the impedance of the antenna (z):

$$P_t = \frac{(V_{rms})^2}{z} \qquad \text{(Watts)} \qquad (1)$$

Impedance is equal to the resistance (r) plus a reactance (xi) which is an imaginary number.

$$z = r + xi \qquad (2)$$

An antenna is usually designed so that the reactance is not a factor. Therefore, $xi = 0$ and $z = r$ and thus the impedance can just be considered as the resistance (r). Consequently, the peak transmitted power is:

$$P_t = \frac{(V_{rms})^2}{r} \qquad \text{(Watts)} \qquad (3)$$

A signal radiating from an isotropic antenna, one that radiates uniformly in all directions, would cover a surface area of $4\pi R^2$ at range R. Therefore, the power density at range (R) is:

$$\text{Power density from an isotropic antenna} = \frac{P_t}{4\pi R^2} \qquad \frac{\text{(Watts)}}{\text{(meters squared)}} \qquad (4)$$

However, this equation assumes an antenna that radiates in every direction, and most radars have an antenna that focuses the energy in a specific direction. The amount of focusing power an antenna has is called the gain (G); therefore the benefits of the gain must be taken into account. Thus the power density at range R with a focusing antenna is:

$$\text{Power density from a focusing antenna} = \frac{P_t G}{4\pi R^2} \qquad \frac{\text{(Watts)}}{\text{(meters squared)}} \qquad (5)$$

The re-radiated power (P_r) (power received from the target) is equal to the power from the focusing antenna, from equation 5, multiplied by the cross section of the target (σ), and divided by the surface area of the sphere of radius or range R. Therefore, the power density from the target is:

$$\text{Power density at the receiving antenna} = \frac{\dfrac{P_t G \sigma}{(4\pi)R^2}}{(4\pi)R^2}$$

$$= \frac{P_t G \sigma}{(4\pi)^2 R^4} \qquad \frac{\text{(Watts)}}{\text{(meters squared)}} \qquad (6)$$

Power received at the antenna terminals must take into account the effective aperture of the receiving antenna (A_e), which is equal to the antenna gain (G) multiplied by the wavelength (λ) squared, divided by (4π)

$$A_e = \frac{G\lambda^2}{(4\pi)} \qquad \text{(meters squared)} \qquad (7)$$

Hence, the received power (P_r) at the antenna terminals is equal to equation 6 multiplied by the benefits of the antenna aperture (A_e), otherwise:

$$P_r = \frac{P_t G \sigma (A_e)}{(4\pi)^2 R^4}$$

$$= \frac{P_t G \sigma (G\lambda^2)}{(4\pi)^2 R^4 (4\pi)}$$

$$= \frac{P_t G^2 \sigma \lambda^2}{(4\pi)^3 R^4} \qquad \text{(Watts)} \qquad (8)$$

Note: This assumes the same antenna is used to transmit as well as receive (monostatic). If this were not the case, two variables for antenna gain would be given.

This received power must also take into account the product of the system losses (L). The received power multiplied by the losses is now the total strength of the signal (S). Therefore:

$$S = P_r L \qquad \text{(Watts)} \qquad (9)$$

and,

$$S = \frac{P_t G^2 \lambda^2 L}{(4\pi)^3 R^4} \qquad \frac{\text{(Watts)}}{\text{(meters squared)}} \qquad (10)$$

Every system will have unwanted interference or noise. Noise voltage (root mean squared) squared or simply mean squared noise voltage is equal to 4 times the product of Boltzman's constant (k), absolute temperature (T) also sometimes referred to as the effective input temperature of the system (10:19), the bandwidth (B), and the resistance (r) of the system. Thus the equation to calculate the noise from a system is as follows:

$$V_{rms}{}^2 = 4kTBr$$

or

$$V_{rms} = 2(kTBr)^{1/2} \qquad \text{(volts)} \qquad (11)$$

At most, only half of the noise voltage is sent as available power to the receiver, due to the resistance of the generator and resistance of the receiver being in series. Therefore, the noise voltage at the receiver is equal to:

$$V_{rms} = \frac{2(kTBr)^{1/2}}{2}$$

$$= (kTBr)^{1/2} \qquad \text{(volts)} \qquad (12)$$

From equation 1, the thermal noise power (P_n) at the receiver is equal to the volts (root mean squared) squared divided by resistance:

$$P_n = \frac{(V_{rms})^2}{r}$$

$$= \frac{kTBr}{r}$$

$$= kTB \qquad (13)$$

However, this only includes thermal noise. Noise from outside sources is also a factor, but the effect is included in the value of T_s.

Instead of using system noise temperatures, the noise of a receiver can be described by a Noise Figure (NF). The two-port noise figure is equal to the signal-to-noise ratio of the incoming signal $(S/N)_I$ divided by the signal-to-noise ratio of the outgoing signal $(S/N)_O$.

$$(NF) = \frac{(S/N)_I}{(S/N)_O} \tag{14}$$

The total noise performance of a receiver system can be defined using the operating system noise figure or alternatively the standard system noise figure (F_s). (10:19) The standard system noise figure is always greater than or equal to zero, and the only time it could equal zero is if the receiver is a noiseless receiver, which is impossible in practice. Thus P_n or just noise (N) is:

$$\begin{aligned} N &= P_n \\ &= kT_oB(F_s) \qquad \text{(Watts)} \end{aligned} \tag{15}$$

where T_o is equal to 290°K.

A signal-to-noise equation is just the ratio of the signal power to the noise power, therefore:

$$S/N = \frac{P_tG^2\sigma\lambda^2L}{(4\pi)^3R^4(kT_oB)F_s} \tag{16}$$

Radar Range Equation. The range equation is simply solving for R in equation 16, thus:

$$R = \left(\frac{P_t\, G^2\, \sigma\, \lambda^2\, L}{(4\pi)^3\, k\, T_o\, B\, F_s\, (S/N)} \right)^{1/4} \qquad \text{(meters)} \tag{17}$$

Answers to Subsidiary Questions

Question 1. Is there a decision point in a generic continuous wave (CW) radar for which a minimum signal-to-noise (S/N) ratio is meaningful?

Answer 1. The decision points in a generic CW radar for which a minimum S/N ratio is meaningful depend on the bandwidth of the radar in question. The integration time of the radar should be approximately equal to the reciprocal of two times the Doppler filter bandwidth. Thus, independent target/no target decisions can be made every 1/2B seconds.

Goldman indicates that "The duration t_0 of a significant time interval of the signal is determined by the inherent limited bandwidth of the signal. (8:584) He continues by writing,

> ...if a signal has passed through a transmission system having more or less uniform transmission over a frequency bandwidth B, the smallest time intervals into which we can separate the portions of the signal such that amplitudes of the individual intervals shall be separately significant will have a duration of approximately
>
> $$t_0 = 1/2B \tag{18}$$
>
> (8:584)

D'Ortenzio also illustrates this in his article "Introductory Statistics and Sampling Concepts Applied to Radar Evaluation". (6:129)

This relationship can be demonstrated by a computer program written by Dr. Krile in the Basic programming language. To create this graph 1024 Gausian random numbers were generated to simulate noise samples. The noise was passed through digital filters of various widths (20Hz, 50Hz, 200Hz, 500Hz, and 1000Hz). The autocorrelation function of the outputs were then generated and the resulting graph is shown below:

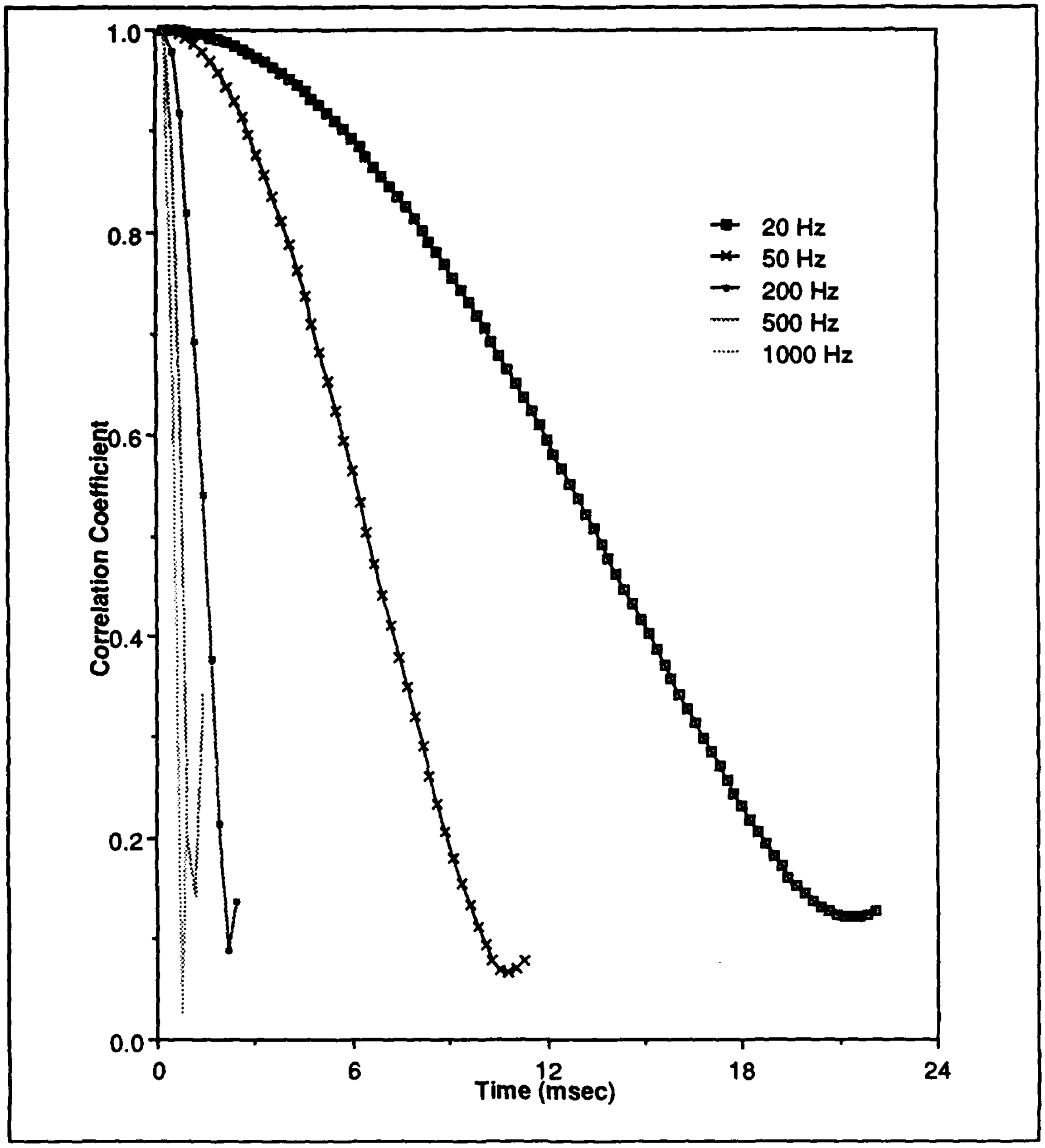


Figure 3. Correlation Coefficient versus Time

The first minimum correlation coefficient of each filter with its appropriate sample number is shown below:

Table I. Minimum Correlation Coefficients

Bandwidth(Hz)	Correlation Coefficient	Sample Number
20	0.12129840	89
50	0.06685939	45
200	0.08794554	9
500	0.14438210	5
1000	0.02683260	3

There are 1024 samples and the total time of the samples is 1/4 of a second, thus the value of each unit is:

$$0.25/1024 = 0.00024414 \qquad \text{(seconds/sample)} \qquad (19)$$

Therefore at each minimum point the total number of samples multiplied by the value of the units will give you the appropriate integration time, namely 1/2B where B is the Bandwidth. Thus:

Table II. Calculations of 1/2B

Bandwidth(Hz)	Sample	*	Unit	=	Value(secs)	1/2B(secs)
20	89		0.000244		0.0217	0.0250
50	45		0.000244		0.0110	0.0100
200	9		0.000244		0.0022	0.0025
500	5		0.000244		0.0012	0.0010
1000	3		0.000244		0.0007	0.0005

As can be seen from the table above, the integration time is approximately the inverse of two times the bandwidth.

Question 2. If there is a decision point in a generic CW radar for which a minimum signal-to-noise ratio is meaningful, are all CW functions disabled when the minimum S/N ratio is not attained?

Answer 2. If a minimum S/N ratio is not met, the functions of the radar are not disabled, the probability of detection is reduced because the probability of detection and probability of false alarm determine the minimum required S/N ratio.

Question 3. Stochastic theory applies for discrete systems such as pulsed radar. Can it be applied to CW systems as well?

Answer 3. Stochastic theory can be applied to CW systems because, in CW systems, target detect/no detect decisions are made at discrete time intervals.

Question 4. As the Pulse Repetition Frequency (PRF) of a pulsed radar increases, (if the pulse width is not decreased) the duty cycle approaches 1.00. The duty cycle of a CW radar is 1.00. Can we assume from this that discontinuities do not exist in the transition from a discrete function (pulsed radar) to a continuous function (CW radar)?

Answer 4. An assumption of no discontinuities is not justified because if the limit of the duty cycle were equal to one for a pulse-Doppler radar, you would not detect anything because the receiver is permanently off.

Question 5. If it is shown that a stochastic description of a minimum S/N ratio for CW radar is undefined, is there a non-stochastic definition that is verifiable and generic?

Answer 5. Stochastic theory does apply to CW systems (see answer 3).

IV. METHODOLOGY

Application of Response Surface Methodology to EWIR

> In a radar detection environment the statistics of target signal and clutter process are seldom known in advance, as they are varying both temporally and spatially. Thus it is desirable to express the received signal in terms of some type of linear model... (16:808)
> For technical or economical reasons, it is frequently not possible to experimentally verify the performance of a radar over its complete range of operation. If measurements can be made at short range, it is desirable to be able to extrapolate these measurements to predict performance at far ranges. It is also desirable to know precisely the effect of the radar's design parameters on its performance so that the design can be optimized. (15:38)

The process of response surface methodology applies linear regression to fit a linear equation to data. It identifies the affect of the radars design parameters on its performance, this is the reason why this technique was used on the EWIR parameters.

The first step in the process of applying the method of response surface methodology was to extract data from the EWIR database. Five radars were chosen from the EWIR database and were labeled Radar A, B, C, X, and Y. The parameters that were extracted from the database were Power (P), Antenna Gain (G) (two antenna gains were used where appropriate), Frequency (F), Noise Figure (NF), Losses (L), and Bandwidth (B). Since each of these parameters had confidence factors associated with them (indicating the degree of confidence in that parameter), a range of inaccuracy of this parameter was established based on these confidence factors.

Four different designs were created using different values for the appropriate confidence factors. Design 1 used a 0%, 5%, 10%, and 15% range of accuracy for a confidence factor of 1, 2, 3, and 4 respectively. For a confidence factor of one, the actual numbers for high and low values were used (0% range of inaccuracy). For a confidence factor of two, a range of plus or minus five percent was created. For a confidence factor of three a range of ten percent was created. Finally, for a confidence factor of four, a range of fifteen percent was created. Therefore for a confidence factor of two, the low

value was multiplied by 0.95 and the high value was multiplied by a value of 1.05. The low and high values were multiplied by 0.9 and 1.1 respectively for a confidence factor of 3. For a confidence factor of 4 the low and high values were multiplied by 0.85 and 1.15 respectively. The sets of designs with their appropriate ranges of inaccuracy and multipliers are shown below:

Table III. Designs and Associated Confidence Factors

Design	Confidence Factor	Range of Inaccuracy	Multiplier Low	Multiplier High
1	1	0.0%	1.0	1.0
	2	5.0%	0.95	1.05
	3	10.0%	0.9	1.1
	4	15.0%	0.85	1.15
2	1	0.0%	1.0	1.0
	2	10.0%	0.9	1.1
	3	20.0%	0.8	1.2
	4	30.0%	0.7	1.3
3	1	10.0%	0.9	1.1
	2	20.0%	0.8	1.2
	3	30.0%	0.7	1.3
	4	40.0%	0.6	1.4
4	1	20.0%	0.8	1.2
	2	30.0%	0.7	1.3
	3	40.0%	0.6	1.4
	4	50.0%	0.5	1.5

The extraction of the parameters from the EWIR database resulted in six ranges of inaccuracy for the six parameters. The next step was to supply a radar cross section and a temperature. The radar cross section was given a range of 5.0 to 30.0 square meters, and the temperature was allowed to range from 273.0 to 300.0 degrees Kelvin. These were ranges suggested by Dr. Krile.

The final parameter to obtain was the required signal-to-noise ratio. Instead of using a single figure for this number, a range was created using the "extreme" values of

the Probability of False Alarm (PFA), Probability of Detection (PD), and Number of pulses incoherently integrated (N). These three were used instead of the single number of signal-to-noise ratio in order to analyze the main effects of each, and their interactions on the radar range. These numbers were extracted from DiFranco and Rubin for a Swerling case I target. (5:380,384) The numbers used for each were:

Table IV. High and Low Settings of PFA, PD, and N

	Low	High
PFA	$0.693/10^{10}$	$0.693/10^{1}$
PD	15.0	97.0
N	1	10

These three ranges varied in all possible ways resulting in eight different required signal-to-noise (S/N) ratios. These were:

Table V. S/N Values and Settings of PFA, PD, and N

PFA	PD	N	S/N (dB)
-1	-1	-1[A]	10.62[B]
1	-1	-1	-3.25
-1	1	-1	29.37
1	1	-1	19.37
-1	-1	1	2.8125
1	-1	1	-9.0625
-1	1	1	20.9375
1	1	1	12.81

[A]-1 denotes the low setting and 1 denotes the high setting.
[B]A three dB correction factor has been subtracted from the chart values of DiFranco and Rubin because the S/N ratios are recorded at the intermediate frequency amplifier not after the detector. (5:376)

Once these intervals were derived an applicable design was created. Using the six factors from the EWIR database, the two for radar cross section and temperature, and using the three parameters of probability of false alarm, probability of detection, and

number of pulses incoherently integrated, an 11 factor design would be needed (12 factors where two antenna gains were used).

It was important that the two-way interactions and the main effects be independent of three-way and higher interactions and therefore a design of resolution V was needed. This design confounds the main effects with four-factor interactions, and two-factor interactions are confounded with three-factor interactions. This type of design allows an unbiased estimation of all main effects and two-factor interactions.

A fractional factorial design was desired due to the reduced number of runs required. Box and Draper provides an applicable design with the appropriate generators. (3:163) The designs that were presented were only for factors of 11 or less. The 11 factor design was used for the radars with 11 factors (2_V^{11-4}) but for those with 12 factors another source had to be consulted. Montgomery offers only designs for 10 factors or less. (11:338-339)

A reference in Montgomery's book to an article by Box and Hunter for more Resolution V designs was mentioned. This article was reviewed but did not have a design of resolution V with 12 factors. (4:449-458)

Since a design of 11 factors was presented in Box and Draper's book, a 12 factor design was extrapolated from this design. The extrapolated design is a sixteenth fraction of resolution V and thus would require 256 runs. The method of introducing the remaining 4 factors for the design were generated using the following:

Table VI. Creation of the 12 Factor Design

Column	Confounding Columns
9	1237
(10)	2345
(11)	1346
(12)	12345678

This design was checked to insure its resolution was in fact a resolution V. Confounding the last four columns in all possible ways with themselves resulted in the following:

Table VII. Confounding Columns of the 12 Factor Design

Columns	Confounding Columns
9	1237
(10)	2345
(11)	1346
(12)	12345678
9(10)	14579(10)
9(11)	24679(11)
9(12)	45689(12)
(10)(11)	1256(10)(11)
(10)(12)	1678(10)(12)
(11)(12)	2578(11)(12)
9(10)(11)	35679(10)(11)
9(10)(12)	23689(10)(12)
(10)(11)(12)	3478(10)(11)(12)
9(11)(12)	13589(11)(12)
9(10)(11)(12)	12489(10)(11)(12)

As can be seen from the Confounding Columns column there is no entry with less than four columns, and thus a design of resolution V has been created (I = 12379, 2345(10), 1346(11), 12345678(12)). Therefore the design created was a 2_{V}^{12-4} design and the core design used was a 2^8 design requiring 256 runs.

Programs

Using the radar range equation and the Fortran programming language, a computer program was created that would read in the z matrix (the matrix that sets whether the parameter is high or low) and as its output, would append the range calculated with the parameters at their appropriate settings. Two Fortran programs and two z matrices were created to calculate ranges for radars with 11 and 12 factors. For

example, the following could be a row of settings from a z matrix that would be read into the program:

Table VIII. Settings of Factors in a Z Matrix

-1	-1	-1	-1	-1	-1	-1	1	1	1	-1

This could produce a range in meters of 8478.8388672 from a certain radar and the output from the Fortran program would be:

Table IX. Sample of an Output from the Fortran Program

-1	-1	-1	-1	-1	-1	-1	1	1	1	-1	8478.8388672

Each column is the setting for a given parameter and is always in the order of Power (P), Gain (G), Frequency (F), Noise Figure (NF), Losses (L), Bandwidth (B), Radar cross section (RCS), Temperature (T), Probability of False Alarm (PFA), Probability of Detection (PD), and Number of pulses Incoherently Integrated (N).

Response surface methodology uses an equation to translate the data from values to numbers between 1.0 and -1.0. The high values become 1.0 and the low values become -1.0. This is accomplished by subtracting the average of the high and low values and dividing by half the difference between the high and low values. For example, using Design 3 on Radar A with a high Power value of 405.6 watts and a low Power value of 218.4 watts, the translation equation is:

$$\frac{X - 312}{93.6} \tag{20}$$

An example of the Fortran programs used to calculate the range for the radars (11 and 12 factors) using design 3 is in Appendix A and B respectively. The programs in Appendix A and B were used for radars A and X respectively. Once the range for each radar was calculated, a Statistical Analysis System (SAS) program was created to apply the technique of response surface methodology to the calculated data. The SAS

programs for radar A and X are in Appendix C and D respectively. The output from the SAS programs gave the Analysis of Variance Tables (ANOVA), residual plots, the coefficients for each linear equation, and the ranking of the most significant effects on the radar range.

Assumptions

1. It is assumed that the confidence factors and their respective percentage ranges from design 3 used to calculate the coefficients for each linear equation are appropriate.

2. It is assumed that the values chosen for the parameters not in the EWIR database (radar cross section, temperature, probability of false alarm, probability of detection, and number of pulses incoherently integrated) are appropriate.

3. Since the EWIR database contains a parameter labeled Noise Figure, it is assumed this is the standard system noise figure.

Verification

The Fortran code that calculates radar ranges was verified by Dr. Krile as being accurate. The values retrieved from the EWIR database were also reviewed by Dr. Krile as being the correct parameters to use in the calculation of the radar range. The percentages used to create the accuracy ranges in design 3 was confirmed as applicable by Mr. Crager from the Air Force Electronic Warfare Center, Kelly AFB. The Basic program used to exemplify the effect of the bandwidth on the integration time used by Dr. Krile has been verified as accurate by him and others. The designs for the SAS programs have been verified as accurate by Major Kenneth Bauer and Dr. Pana Nagarsenka from the Air Force Institute of Technology.

Validation

The radar range is an equation that has been used since the Second World War and has been proven to be an accurate determination of a radars range. The process of response surface methodology is also a proven technique that has been proven by many as a technique used to estimate an equation to data. (3:1)

V. Findings and Analysis

Fractional Factorial Designs

When the initial runs were analyzed, the adjusted R-squared values averaged approximately 0.97. The residual plots, however, indicated a quadratic tendency, so Box and Draper (1987) was consulted to solve this problem.

Due to this strong dependence shown in the residual plots, a transformation of the data was needed. (3:210) This transformation was accomplished by computing the logarithm of the range as the output of the Fortran program. Once this transformation was complete, the designs were run again. The residual plot from each radar revealed no dependent relationship, and thus a more accurate estimation of the data resulted. The following is a summary of the SAS output for each radar for each design, however a complete output for each radar using design 3 is in Appendix E-I.

The R-squared value and adjusted R-squared value for each radar using all four designs were both 1.0. The following is a summary of the significant effects from all radars from each design:

Significant Effects*

Table X. Significant Effects Using the Fractional Factorial Design for Designs 1-4

	Radar A				Radar B			
Design	1	2	3	4	1	2	3	4
	PD	G	G	G	PD	G	G	G
	G	PD	PD	PD	G	PD	PD	PD
	PFA	PFA	PFA	PFA	PFA	PFA	PFA	PFA
	RCS	RCS	RCS	F	RCS	RCS	RCS	NF
	N	N	N	RCS	N	N	N	F
	F	F	F	N	F	F	NF	RCS
	PFAPD	PFAPD	P	P	NF	NF	F	N
	PFAN	B	B	B	PFAPD	PFAPD	B	B
	P	P	NF	NF	PFAN	B	PFAPD	P
	B	NF	PFAPD	PFAPD	B	L	L	L
	NF	PFAN	PFAN	L	L	PFAN	P	PFAPD
	T	L	L	PFAN	P	P	PFAN	PFAN
	PDN	T	T	T	T	T	T	T
	L	PDN	PDN	PDN	PDN	PDN	PDN	PDN

Radar C

Design	1	2	3	4
	PD	G	G	G
	G	PD	PD	PD
	PFA	PFA	PFA	PFA
	RCS	RCS	RCS	NF
	N	N	N	F
	F	NF	NF	RCS
	NF	F	F	N
	PFAPD	PFAPD	B	B
	PFAN	B	PFAPD	P
	B	L	P	L
	L	PFAN	L	PFAPD
	P	P	PFAN	PFAN
	T	T	T	T
	PDN	PDN	PDN	PDN

Radar X / **Radar Y**

Design	X 1	X 2	X 3	X 4	Y 1	Y 2	Y 3	Y 4
	PD	PD	GT	GT	PD	PD	PD	GT
	P	GT	GR	GR	PFA	PFA	GT	PD
	PFA	GR	PD	PD	RCS	NF	PFA	NF
	GT	P	P	P	N	RCS	NF	GR
	GR	PFA	PFA	PFA	NF	GT	GR	PFA
	RCS	RCS	RCS	F	GT	N	RCS	RCS
	N	N	N	RCS	GR	GR	N	N
	F	F	F	N	PFAPD	PFAPD	F	F
	PFAPD	NF	NF	NF	PFAN	B	B	B
	NF	PFAPD	B	B	F	F	L	L
	PFAN	L	L	L	B	L	PFAPD	P
	L	B	PFAPD	PFAPD	L	PFAN	P	PFAPD
	B	PFAN	PFAN	PFAN	P	P	PFAN	PFAN
	T	T	T	T	T	T	T	T
	PDN	PDN	PDN	PDN	PDN	PDN	PDN	PDN

*The letters PFAPD, PFAN, and PDN denote the two-way interactions of the Probability of False alarm and Probability of Detection, Probability of False Alarm and Number of Pulses incoherently integrated, and Probability of Detection and Number of Pulses integrated respectively. The letters GT and GR for the radars X and Y denote the gain of the transmitting and receiving antenna respectively.

Linear Equations

The linear equation using the fractional factorial design for each radar using each design (1-4) is as follows:

Table XI. Linear Equations using the Fractional Factorial Design for Designs 1-4

Design 1

Radar A:

5.338	- 0.254PD	+ 0.18G	+ 0.137PFA
+ 0.097RCS	+ 0.089N	- 0.038F	- 0.024PFAPD
- 0.012PFAN	+ 0.011P	- 0.011B	- 0.006NF
- 0.005T	+ 0.004PDN	- 0.004L	

Radar B:

4.894	- 0.254PD	+ 0.175G	+ 0.137PFA
+ 0.097RCS	+ 0.089N	- 0.028F	- 0.025NF
- 0.024PFAPD	- 0.012PFAN	- 0.011B	- 0.008L
+ 0.005P	- 0.005T	+ 0.004PDN	

Radar C:

4.859	- 0.254PD	+ 0.195G	+ 0.137PFA
+ 0.097RCS	+ 0.089N	- 0.030F	- 0.029NF
- 0.024PFAPD	- 0.012PFAN	- 0.011B	- 0.006L
+ 0.005P	- 0.005T	+ 0.004PDN	

Radar X:

5.493	- 0.254PD	+ 0.204P	+ 0.137PFA
+ 0.123GT	+ 0.113GR	+ 0.097RCS	+ 0.089N
- 0.030F	- 0.024PFAPD	- 0.023NF	- 0.012PFAN
- 0.011L	- 0.011B	- 0.005T	+ 0.004PDN

Radar Y:

4.096	- 0.254PD	+ 0.137PFA	+ 0.097RCS
+ 0.089N	- 0.065NF	+ 0.048GT	+ 0.027GR
- 0.024PFAPD	- 0.012PFAN	- 0.011F	- 0.011B
- 0.010L	+ 0.005P	- 0.005T	+ 0.004PDN

Design 2

Radar A:

5.34	+ 0.360G	- 0.254PD	+ 0.137PFA
+ 0.097RCS	+ 0.089N	- 0.061F	- 0.024PFAPD
- 0.022B	+ 0.022P	- 0.013NF	- 0.012PFAN
- 0.008L	- 0.005T	+ 0.004PDN	

Radar B:

4.898	+ 0.350G	- 0.254PD	+ 0.137PFA
+ 0.097RCS	+ 0.089N	- 0.051F	- 0.050NF
- 0.024PFAPD	- 0.022B	- 0.015L	- 0.012PFAN
+ 0.011P	- 0.005T	+ 0.004PDN	

Radar C:

4.864 + 0.390G - 0.254PD + 0.137PFA
+ 0.097RCS + 0.089N - 0.058NF - 0.052F
- 0.024PFAPD - 0.022B - 0.013L - 0.012PFAN
+ 0.011P - 0.005T + 0.004PDN

Radar X:

5.496 - 0.254PD + 0.247GT + 0.227GR
+ 0.215P + 0.137PFA + 0.097RCS + 0.089N
- 0.053F - 0.045NF - 0.024PFAPD - 0.023L
- 0.022B - 0.012PFAN - 0.005T + 0.004PDN

Radar Y:

4.095 - 0.254PD + 0.137PFA - 0.100NF
+ 0.097RCS + 0.095GT + 0.089N + 0.055GR
- 0.024PFAPD - 0.022B - 0.022F - 0.021L
- 0.012PFAN + 0.011P - 0.005T + 0.004PDN

Design 3

Radar A:

5.347 + 0.540G - 0.254PD + 0.137PFA
+ 0.097RCS + 0.089N - 0.084F + 0.034P
- 0.034B - 0.025NF - 0.024PFAPD - 0.012PFAN
- 0.012L - 0.005T + 0.004PDN

Radar B:

4.905 + 0.525G - 0.254PD + 0.137PFA
+ 0.097RCS + 0.089N - 0.075NF - 0.074F
- 0.034B - 0.024PFAPD - 0.023L + 0.022P
- 0.012PFAN - 0.005T + 0.004PDN

Radar C:

4.871 + 0.585G - 0.254PD + 0.137PFA
+ 0.097RCS + 0.089N - 0.086NF - 0.075F
- 0.034B - 0.024PFAPD + 0.022P - 0.019L
- 0.012PFAN - 0.005T + 0.004PDN

Radar X:

5.502 + 0.370GT + 0.340GR - 0.254PD
+ 0.227P + 0.137PFA + 0.097RCS + 0.089N
- 0.076F - 0.060NF - 0.034B - 0.030L
- 0.024PFAPD - 0.012PFAN - 0.005T + 0.004PDN

Radar Y:

4.10 - 0.254PD + 0.190GT + 0.137PFA
- 0.135NF + 0.110GR + 0.097RCS + 0.089N
- 0.044F - 0.034B - 0.031L - 0.024PFAPD
+ 0.022P - 0.012PFAN - 0.005T + 0.004PDN

Design 4

Radar A:

5.356	+ 0.720G	- 0.254PD	+ 0.137PFA
- 0.109F	+ 0.097RCS	+ 0.089N	+ 0.046P
- 0.046B	- 0.038NF	- 0.024PFAPD	- 0.016L
- 0.012PFAN	- 0.005T	+ 0.004PDN	

Radar B:

4.916	+0.700G	- 0.254PD	+ 0.137PFA
- 0.100NF	- 0.099F	+ 0.097RCS	+ 0.089N
- 0.046B	+0.034P	- 0.030L	- 0.024PFAPD
- 0.012PFAN	- 0.005T	+ 0.004PDN	

Radar C:

4.881	+0.780G	- 0.254PD	+ 0.137PFA
- 0.115NF	- 0.100F	+0.097RCS	+ 0.089N
- 0.046B	+0.046P	- 0.025L	- 0.024PFAPD
- 0.012PFAN	- 0.005T	+0.004PDN	

Radar X:

5.510	+ 0.493GT	+ 0.453GR	- 0.254PD
+ 0.239P	+ 0.137PFA	- 0.101F	+ 0.097RCS
+ 0.089N	- 0.075NF	- 0.046B	- 0.0375L
- 0.024PFAPD	- 0.012PFAN	- 0.005T	+ 0.004PDN

Radar Y:

4.101	+ 0.285GT	- 0.254PD	- 0.170NF
+ 0.165GR	+ 0.137PFA	+ 0.097RCS	+ 0.089N
- 0.067F	- 0.046B	- 0.041L	+ 0.034P
- 0.024PFAPD	- 0.012PFAN	- 0.005T	+ 0.004PDN

Full Factorial Designs

Since the fractional factorial designs were analyzed and it was discovered that they contained some error, albeit less than 10%, a full factorial design was run for each radar. For the 11 factor radars this required 2048 runs, and for the 12 factor case this required 4096 runs. The Fortran programs (Appendix A and B) were modified to accept the appropriate number of runs. The results are as follows:

Table XII. R-Squared and Adjusted R-Squared Values for Design 3 using the Full Factorial Design

	A	B	C	X	Y
R-Squared	.9982	.9981	.9984	.9982	.9958
Adjusted R-Squared	.9981	.9981	.9984	.9982	.9957

Table XIII. Significant Effects using the Full Factorial Design for Design 3

Radar	A	B	C	X	Y
	G	G	G	GT	PD
	PD	PD	PD	GR	GT
	PFA	PFA	PFA	PD	PFA
	RCS	RCS	RCS	P	NF
	N	N	N	PFA	GR
	F	NF	NF	RCS	RCS
	P	F	F	N	N
	B	B	B	F	F
	NF	L	P	NF	B
	L	P	L	B	L
	T	T	T	L	P
				T	T

The fractional factorial design contained some "noise" and introduced the two-way interaction terms to account for this. As can be seen from this table, the full factorial design contains no two-way interaction terms and thus less "noise". Two-way interactions were not expected in these designs (except PFA, PD, and N because the interactions of these factors was not known) because the radar range equation is linear in the logarithmic scale, thus no interaction among the terms.

Table XIV. Linear Equations using the Full Factorial Design for Design 3

Radar A:				
	5.347	+ 0.540G	- 0.254PD	+ 0.137PFA
	+ 0.097RCS	+ 0.089N	- 0.084F	+ 0.034P
	- 0.034B	- 0.025NF	- 0.012L	- 0.005T
Radar B:				
	4.905	+ 0.525G	- 0.254PD	+ 0.137PFA
	+ 0.097RCS	+ 0.089N	- 0.075NF	- 0.074F
	- 0.034B	- 0.023L	+ 0.022P	- 0.005T
Radar C:				
	4.871	+ 0.585G	- 0.254PD	+ 0.137PFA
	+ 0.097RCS	+ 0.089N	- 0.086NF	- 0.075F
	- 0.034B	+ 0.022P	- 0.019L	- 0.005T
Radar X:				
	5.502	+ 0.370GT	+ 0.340GR	- 0.254PD
	+ 0.227P	+ 0.137PFA	+ 0.097RCS	+ 0.089N
	- 0.076F	- 0.060NF	- 0.034B	- 0.030L
	- 0.005T			
Radar Y:				
	4.10	- 0.254PD	+ 0.190GT	+ 0.137PFA
	- 0.135NF	+ 0.110GR	+ 0.097RCS	+ 0.089N
	- 0.044F	- 0.034B	- 0.031L	+ 0.022P
	- 0.005T			

As can be seen from above, the full factorial design mainly reinforces the design created for the 12 factor radars. The significant effects were in the exact same order, and the coefficients were identical.

Reduced Models

Using the standard of an R-squared of 99% the significant effects from design 3 for all radars were chosen. The following shows the significant effects for each radar to achieve a 99% R-squared using design 3.

Table XV. Significant Effects for the Reduced Models using an R-Squared Value of 99%

Radar A	Radar B	Radar C	Radar X	Radar Y
G	G	G	GT	PD
PD	PD	PD	GR	GT
PFA	PFA	PFA	PD	PFA
RCS	RCS	RCS	P	NF
N	N	N	PFA	GR
F	NF	NF	RCS	RCS
	F	F	N	N
			F	F
			NF	B
				L

To achieve a 99% model R-squared, some radars need more effects than others. This indicates the degree of accuracy needed for a particular radar. If there were many significant effects, the radar could only be modeled effectively using them all. If there were few effects, this indicates that only a few variables are significant and thus much more accuracy is needed to reduce their significance, so other factors become significant as in the case of Radar Y above. For example, radar Y uses 10 of its 12 variables to estimate its range whereas radar A uses only 6 out of 11. This indicates that the estimation of the parameters in Radar Y was sufficiently accurate relative to their relationship in the radar range equation.

The linear equation for each radar using, a reduced design of the significant effects above while maintaining an R-squared value of 99%, is as follows:

Table XVI. Linear Equations using the Reduced Model for Design 3

Radar A:

$$5.347 + 0.540G - 0.254PD + 0.137PFA + 0.097RCS + 0.089N - 0.084F$$

Radar B:

$$4.905 + 0.525G - 0.254PD + 0.137PFA - 0.099F + 0.097RCS + 0.089N - 0.075NF - 0.074F$$

Radar C:

4.871 + 0.585G - 0.254PD + 0.137PFA + 0.097RCS + 0.089 - 0.086NF - 0.075F

Radar X:

5.502 + 0.370GT + 0.340GR - 0.254PD + 0.227P + 0.137PFA + 0.097RCS + 0.089N -0.076F - 0.060NF

Radar Y:

4.10 - 0.254PD + 0.190GT + 0.137PFA - 0.135NF + 0.110G + 0.097RCS + 0.089N - 0.044F - 0.034B - 0.031L

Maximum Ranges

The following are the maximum ranges in nautical miles for each radar. The arrow at the bottom left of each figure refers to the maximum range of the radar at its optimum setting without regard to the confidence factors (the method presently used in the EWIR database). The legend denotes the maximum range calculated using the reduced design (REDUCED), the full factorial design (FULL), the Fortran program (FORTRAN), and the fractional factorial design (FRACTION).

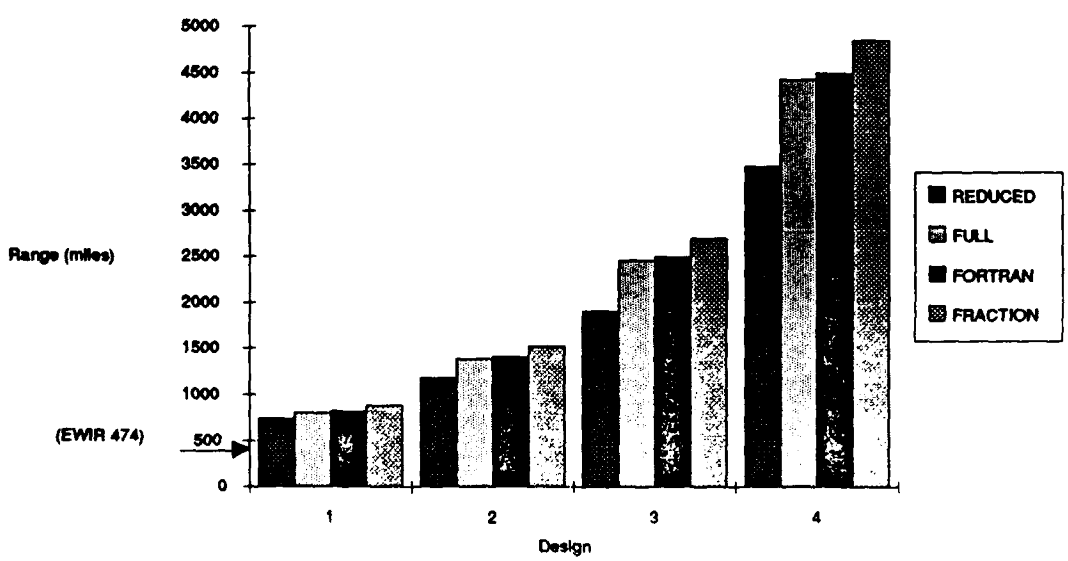


Figure 4. Radar A Maximum Ranges

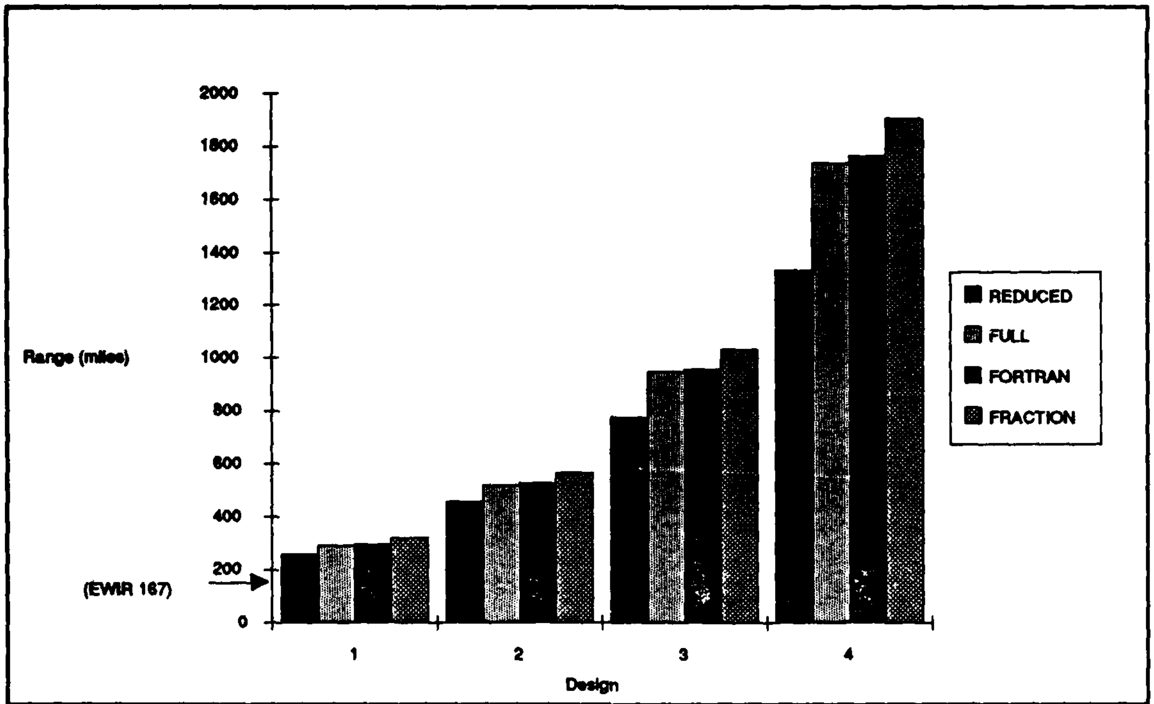


Figure 5. Radar B Maximum Ranges

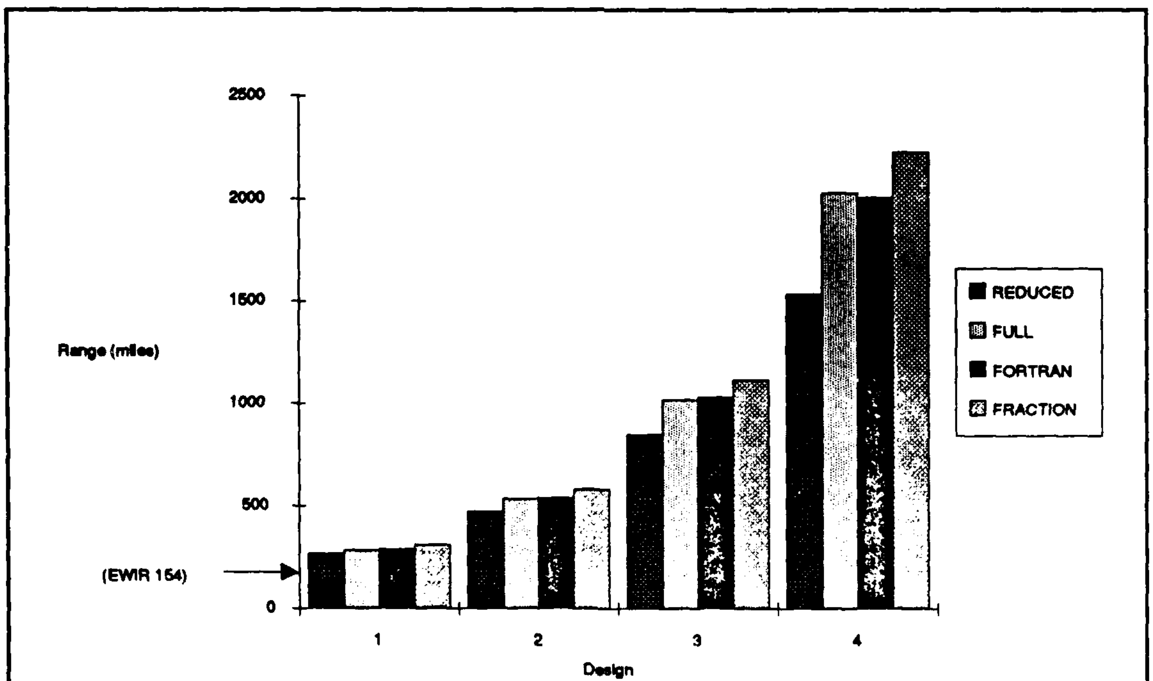


Figure 6. Radar C Maximum Ranges

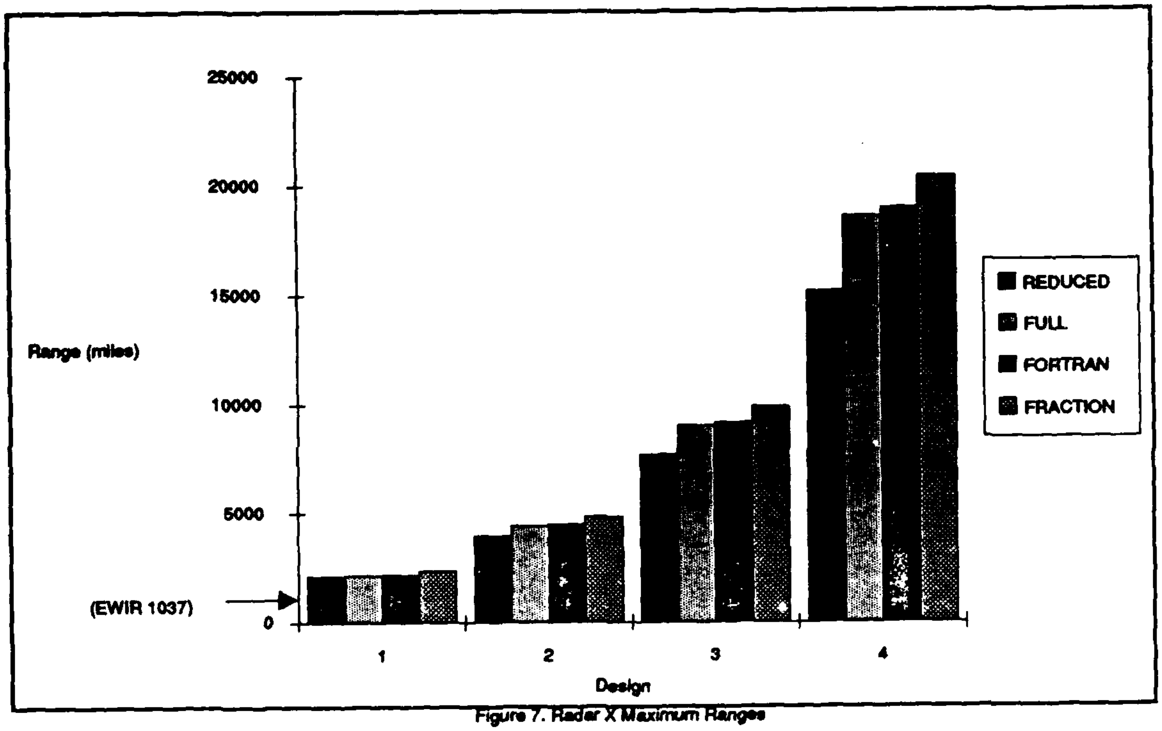


Figure 7. Radar X Maximum Ranges

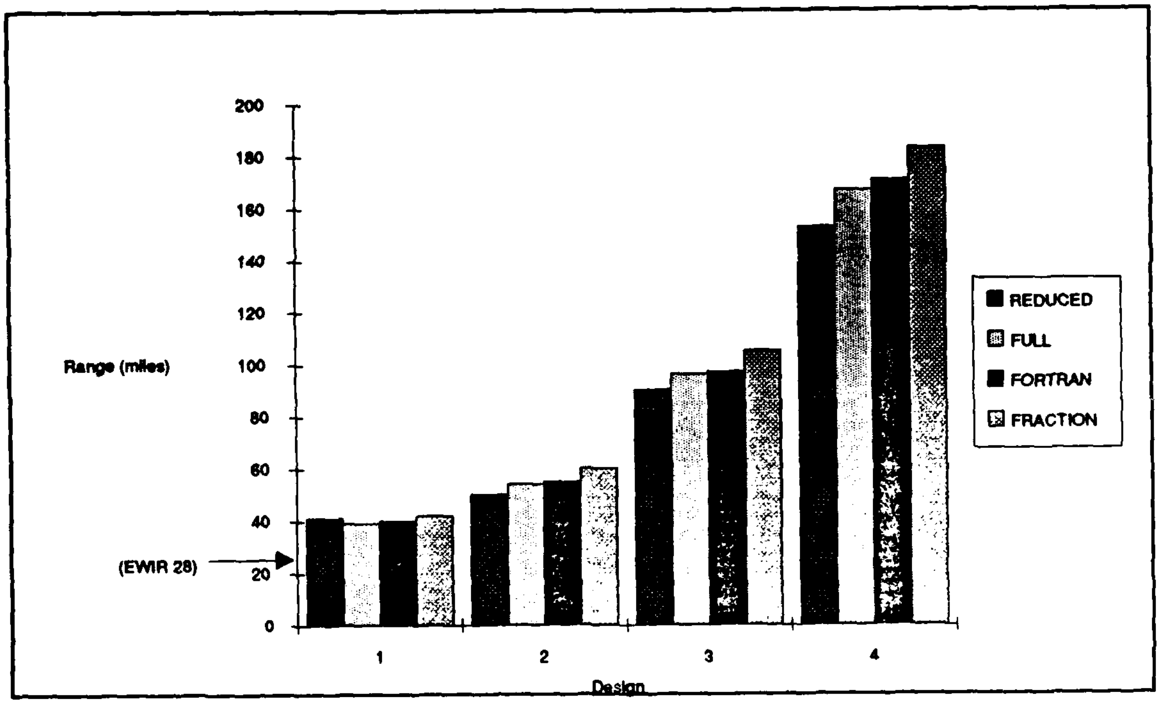


Figure 8. Radar Y Maximum Ranges

As can be seen from above, the most accurate estimation of the maximum range is the full factorial design, then the fractional factorial design, and lastly the reduced design. The difference between the range calculated using the Fortran program and the range calculated using the full linear equation is due to the error inherent in the "linearizing" of the radar range equation. However, none of the ranges using the full linear equation has an error greater than 3%.

The difference between the range calculated using the Fortran program and the range calculated using the full factorial design's linear equation cannot be explained by the residuals, due to the fact that the range is in logarithmic terms. The residuals are the difference between the actual values and the predicted values. Since the range is in logarithmic terms, the residuals are now the logarithm of the actual value divided by the predicted value, and this is not the definition of a residual. Therefore, the residuals cannot explain the adequacy of fit of the model. For example, at the maximum range the *residuals of design 3 are:*

Table XVII. Affect of the Logarithm on the Residuals

	Radar A		
	Actual	Predicted	Difference(miles)
Range(log)	6.6653	6.6582	0.00055
Range(miles)	2498	2458	40
	Radar B		
	Actual	Predicted	Difference(miles)
Range(log)	6.2476	6.2405	0.00055
Range(miles)	955	939	16
	Radar C		
	Actual	Predicted	Difference(miles)
Range(log)	6.2814	6.2743	0.00055
Range(miles)	1032	1015	17

	Radar X		
	Actual	Predicted	Difference(miles)
Range(log)	7.2276	7.2206	0.00055
Range(miles)	9119	8973	146

	Radar Y		
	Actual	Predicted	Difference(miles)
Range(log)	5.2527	5.2456	0.00055
Range(miles)	97	95	2

Since the fractional factorial design is only a partial of the full design, not all possible combinations are included. The optimum combination of:

Table XVIII. Optimal Settings for Maximum Radar Range

P	G	F	NF	L	B	RCS	T	PFA	PD	N
1	1	-1	-1	-1	-1	1	-1	1	-1	1

is not included in the fractional factorial design. The maximum range within this design is not necessarily the maximum range of the radar. Thus the ranges given are the best from the fractional factorial design and will have some error.

The reason the fractional factorial designs have maximum ranges greater than the calculated ranges is due to error. The fractional factorial design tries to estimate the data with 11 (or 12) factors. In trying to estimate this data with a linear equation, some points (the maximum range point) will not be on this line, and thus this distance is the error.

The main ideas that must be remembered, the full linear design is used to identify the significant effects thus allowing to create a reduced design. The reduced design is created to allow the database user to change a variable while noting the change in the range of the radar. The full linear equation can be used for this purpose but it is a little more difficult due to the number of settings and it contains some error.

VI. CONCLUSIONS

Implications

As can be seen from the table of significant effects, as the degree of inaccuracy of estimation increases (confidence factor increases) the importance of the variables in the radar equation increases. All variables, gain, frequency, noise figure, bandwidth, losses, and power all increase in importance in all radars if they are not estimated accurately. The variables, probability of detection, probability of false alarm, radar cross section, and number of pulses integrated all decrease in importance as the confidence factor increases (estimations become more inaccurate). This indicates the relative importance of the variables due to the inherent relationship in the radar range equation and the degree of accuracy required in estimating them. The importance of this finding is that this indicates which variables to concentrate the most time and money on data collection since these variables significantly affect the range of the radar set. The most important factor to be estimated with the highest degree of accuracy is antenna gain. This factor in all radars quickly becomes significant when not estimated accurately.

The range of the radar set also varies if the confidence factor in the database is used. The database calculates range using the point estimates with no range of accuracy involved. As can be seen from the difference in range from design 0 to even design 1 this can be very significant. The confidence factors must be incorporated when calculating range to include this degree of inaccuracy.

The full linear equations can be used in place of the actual radar range for these radars. It can determine the range of the radar without the complicated calculations. The reduced equation is intended to give a quick estimate of the radars range while varying only the most significant variables. This allows a quick calculation of the effects of a better estimation of these variables by analyzing the maximum range of the radar.

Using equation 20, the transformation equation, intermediate values can be computed and substituted into the linear equations and the change in range can be observed. For example, using the reduced equation of radar A, suppose a new estimation of the power is actually 358.8 watts, and not 405.6 watts. This results in a transformed value of 0.5. This better estimation of this parameter results in a range of 2362 miles whereas the inaccurate estimation of power resulted in a maximum range of 2457 miles. This information can be immediately calculated from the linear equation. This type of information can be used to determine whether the cost of estimating the power more accurately is worth the importance of the extra 95 miles, and thus trade-offs can be studied.

Recommendations

The calculation of radar ranges within the database must use the confidence factors associated with the parameters. This gives a database user a more "accurate" capability of a radars range.

The estimation of the radar antenna gain should be the single most important goal in data collection. The other factors of a radars range were significant but none were as significant as the antenna gain.

Future Research

The technique of response surface methodology should be used on other radars within the database to identify the significant effects of other radars.

Goal programming can be used on the linear equations to maximize the range if constraints of the factors involved are known. Given a desired maximim range, the linear equations could be used to meet this goal, subject to cost constraints on the individual constituents.

APPENDIX A:

11 FACTOR FORTRAN PROGRAM FOR RADAR A USING DESIGN 3

```
      COMMON/TABLES/Z(128,11),HILO(11,2),X(11),V(11),O(128,12)
      REAL HILO,Y,RANGE,R(128),FOURPI
      INTEGER Z,I,J
      DATA  HILO/405.6,46.8,3.1785,6.0,2.08,1.56,30.0,300.0,
     +           0.0,97.0,10.0,
     +           218.4,25.2,1.47,4.0,1.12,0.84,5.0,273.0,
     +           0.0,15.0,1.0/
      OPEN(UNIT=70,FILE='Z',STATUS='OLD')
      READ(70,*)  ((Z(I,J),J=1,11),I=1,128)
      WRITE(5,4)  ((Z(I,J),J=1,11),I=1,128)
 4    FORMAT (11(1X,I5))
      HILO(9,1)=0.693/10.0
      HILO(9,2)=0.693/(10.0**10.0)

      DO 10 I=1,128
      DO 20 J=1,11
            V(J)=HILO(J,1)
      IF(Z(I,J).LT.0)  V(J)=HILO(J,2)
      SN = 12.81
      IF((Z(I,9).LT.0).AND.(Z(I,10).GT.0).AND.(Z(I,11).GT.0))SN=20.9375
      IF((Z(I,9).GT.0).AND.(Z(I,10).LT.0).AND.(Z(I,11).GT.0))SN=-9.0625
      IF((Z(I,9).LT.0).AND.(Z(I,10).LT.0).AND.(Z(I,11).GT.0))SN=2.8125
      IF((Z(I,9).GT.0).AND.(Z(I,10).GT.0).AND.(Z(I,11).LT.0))SN=19.37
      IF((Z(I,9).LT.0).AND.(Z(I,10).GT.0).AND.(Z(I,11).LT.0))SN=29.37
      IF((Z(I,9).GT.0).AND.(Z(I,10).LT.0).AND.(Z(I,11).LT.0))SN=-3.25
      IF((Z(I,9).LT.0).AND.(Z(I,10).LT.0).AND.(Z(I,11).LT.0))SN=10.62
20    CONTINUE

      X(1) = 10.0*(LOG10(V(1)*1000.0))
      X(2) = V(2)*2.0
      X(3) = 10.0*2.0*(LOG10(3.0*(10.0**(-1))/V(3)))
      X(4) = V(4)
      X(5) = V(5)
      X(6) = 10.0*(LOG10((V(6))*(10.0D5)))
      X(7) = 10.0*(LOG10(V(7)))
      X(8) = 10.0*(LOG10(V(8)*(1.38*10.0**(-23))))
      FOURPI=10.0*(LOG10((4.0*3.141592654D+00)**3))

      RANGE = X(1)+X(2)+X(3)-X(4)-X(5)-X(6)+X(7)-FOURPI-X(8)-SN
      R(I) = (RANGE/40.0)
 10   CONTINUE

      DO 35 I=1,128
      DO 34 J=1,11
      O(I,J)=Z(I,J)
34    CONTINUE
      O(I,12)=R(I)
      WRITE(16,47)(Z(I,J),J=1,11),R(I)
47    FORMAT(11(1X,I3),F15.7)
35    CONTINUE
      END
```

APPENDIX B:

12 FACTOR FORTRAN PROGRAM FOR RADAR X USING DESIGN 3

```
      COMMON/TABLES/Z(256,12),HILO(12,2),X(12),V(12),O(256,13)
      REAL HILO,Y,RANGE,R(256),FOURPI
      INTEGER Z,I,J
      DATA  HILO/7.28,64.09,58.89,9.2872,8.4,4.2,0.013,30.0,300.0,
     +           0.0,97.0,10.0,
     +           0.112,34.51,31.71,4.6158,3.6,1.8,0.007,5.0,273.0,
     +           0.0,15.0,1.0/
      OPEN(UNIT=70,FILE='Z',STATUS='OLD')
      READ(70,*) ((Z(I,J),J=1,12),I=1,256)
      WRITE(5,4) ((Z(I,J),J=1,12),I=1,256)
4     FORMAT (12(1X,I5))
      HILO(10,1)=0.693/10.0
      HILO(10,2)=0.693/(10.0**10.0)

      DO 10 I=1,256
      DO 20 J=1,12
            V(J)=HILO(J,1)
      IF(Z(I,J).LT.0)  V(J)=HILO(J,2)
      SN = 12.81
      IF((Z(I,10).LT.0).AND.(Z(I,11).GT.0).AND.(Z(I,12).GT.0))SN=20.9375
      IF((Z(I,10).GT.0).AND.(Z(I,11).LT.0).AND.(Z(I,12).GT.0))SN=-9.0625
      IF((Z(I,10).LT.0).AND.(Z(I,11).LT.0).AND.(Z(I,12).GT.0))SN=2.8125
      IF((Z(I,10).GT.0).AND.(Z(I,11).GT.0).AND.(Z(I,12).LT.0))SN=19.37
      IF((Z(I,10).LT.0).AND.(Z(I,11).GT.0).AND.(Z(I,12).LT.0))SN=29.37
      IF((Z(I,10).GT.0).AND.(Z(I,11).LT.0).AND.(Z(I,12).LT.0))SN=-3.25
      IF((Z(I,10).LT.0).AND.(Z(I,11).LT.0).AND.(Z(I,12).LT.0))SN=10.62
20    CONTINUE

      X(1) = 10.0*(LOG10(V(1)*1000.0))
      X(2) = V(2)
      X(3) = V(3)
      X(4) = 10.0*2.0*(LOG10(3.0*(10.0**(-1))/V(4)))
      X(5) = V(5)
      X(6) = V(6)
      X(7) = 10.0*(LOG10((V(7))*(10.0D5)))
      X(8) = 10.0*(LOG10(V(8)))
      X(9) = 10.0*(LOG10(V(9)*(1.38*10.0**(-23))))
      FOURPI=10.0*(LOG10((4.0*3.141592654D+00)**3))
      RANGE = X(1)+X(2)+X(3)+X(4)-X(5)-X(6)-X(7)-FOURPI+X(8)-X(9)-SN
      R(I) = (RANGE/40.0)
10    CONTINUE

      DO 35 I=1,256
      DO 34 J=1,12
      O(I,J)=Z(I,J)
34    CONTINUE
      O(I,13)=R(I)
      WRITE(16,47)(Z(I,J),J=1,12),R(I)
47    FORMAT(12(1X,I3),F15.7)
35    CONTINUE
      END
```

APPENDIX C:

SAS PROGRAM FOR RADAR A

```
options linesize=78;
filename new 'RDRA.dat';
data new;
infile new;
input P G F NF L B RCS T PFA PD N RANGE;

PG=P*G;
PF=P*F;
PNF=P*NF;
PL=P*L;
PB=P*B;
PRCS=P*RCS;
PT=G*F*RCS;
PPFA=P*G*F*NF*L;
PPD=F*NF*B;
PN=G*F*NF*L*B*RCS;
GF=G*F;
GNF=G*NF;
GL=G*L;
GB=G*B;
GRCS=G*RCS;
GT=P*F*RCS;
GPFA=F*NF*L;
GPD=P*G*F*NF*B;
GN=P*F*NF*L*B*RCS;
FNF=F*NF;
FL=F*L;
FB=F*B;
FRCS=F*RCS;
FT=P*G*RCS;
FPFA=G*NF*L;
FPD=P*NF*B;
FN=P*G*NF*L*B*RCS;
NFL=NF*L;
NFB=NF*B;
NFRCS=NF*RCS;
NFT=P*G*F*NF*RCS;
NFPFA=G*F*L;
NFPD=P*F*B;
NFN=P*G*F*L*B*RCS;
LB=L*B;
LRCS=L*RCS;
LT=P*G*F*L*RCS;
LPFA=G*F*NF;
LPD=P*F*NF*L*B;
LN=P*G*F*NF*B*RCS;
BRCS=B*RCS;
BT=P*G*F*B*RCS;
BPFA=G*F*NF*L*B;
BPD=P*F*NF;
BN=P*G*F*NF*L*RCS;
RCST=P*G*F;
RCSPFA=G*F*NF*L*RCS;
RCSPD=P*F*NF*B*RCS;
RCSN=P*G*F*NF*L*B;
```

```
TPFA=P*NF*L*RCS;
TPD=G*NF*B*RCS;
TN=NF*L*B;
PFAPD=P*G*L*B;
PFAN=P*B*RCS;
PDN=G*L*RCS;

PROC PRINT DATA=NEW;
VAR P G F NF L B RCS T PFA PD N PG PF PNF PL PB PRCS PT PPFA PPD PN
GF GNF GL GB GRCS GT GPFA GPD GN FNF FL FB FRCS FT FPFA FPD FN NFL
NFB NFRCS NFT NFPFA NFPD NFN LB LRCS LT LPFA LPD LN BRCS BT BPFA BPD BN
RCST RCSPFA RCSPD RCSN TPFA TPD TN PFAPD PFAN PDN RANGE;

PROC REG DATA=NEW;
 MODEL RANGE= P G F NF L B RCS T PFA PD N PG PF PNF PL PB PRCS PT PPFA PPD PN
GF GNF GL GB GRCS GT GPFA GPD GN FNF FL FB FRCS FT FPFA FPD FN NFL NFB NFRCS
NFT NFPFA NFPD NFN LB LRCS LT LPFA LPD LN BRCS BT BPFA BPD BN RCST RCSPFA
RCSPD RCSN TPFA TPD TN PFAPD PFAN PDN/P;
 OUTPUT OUT=Z R=RESIDUAL;

PROC PLOT DATA=Z;
 PLOT RESIDUAL*RANGE='*';
 TITLE 'RADAR RANGE RESIDUALS';

PROC STEPWISE DATA=NEW;
  model RANGE= P G F NF L B RCS T PFA PD N PG PF PNF PL PB PRCS PT PPFA PPD PN
GF GNF GL GB GRCS GT GPFA GPD GN FNF FL FB FRCS FT FPFA FPD FN NFL NFB NFRCS
NFT NFPFA NFPD NFN LB LRCS LT LPFA LPD LN BRCS BT BPFA BPD BN RCST RCSPFA
RCSPD RCSN TPFA TPD TN PFAPD PFAN PDN/stepwise;
```

APPENDIX D:

SAS PROGRAM FOR RADAR X

```
options linesize=78;
filename new 'RDRX.dat';
data new;
infile new;
input P GT GR F NF L B RCS T PFA PD N RANGE;

PGT=P*GT;
PGR=P*GR;
PF=P*F;
PNF=P*NF;
PL=P*L;
PB=P*B;
PRCS=P*RCS;
PT=GT*GR*B;
PPFA=P*GT*GR*F*NF;
PPD=GR*F*L;
PN=GT*GR*F*NF*L*B*RCS;
GTGR=GT*GR;
GTF=GT*F;
GTNF=GT*NF;
GTL=GT*L;
GTB=GT*B;
GTRCS=GT*RCS;
GTT=P*GR*B;
GTPFA=GR*F*NF;
GTPD=P*GT*GR*F*L;
GTN=P*GR*F*NF*L*B*RCS;
GRF=GR*F;
GRNF=GR*NF;
GRL=GR*L;
GRB=GR*B;
GRRCS=GR*RCS;
GRT=P*GT*B;
GRPFA=GT*F*NF;
GRPD=P*F*L;
GRN=P*GT*F*NF*L*B*RCS;
FNF=F*NF;
FL=F*L;
FB=F*B;
FRCS=F*RCS;
FT=P*GT*GR*F*B;
FPFA=GT*GR*NF;
FPD=P*GR*L;
FN=P*GT*GR*NF*L*B*RCS;
NFL=NF*L;
NFB=NF*B;
NFRCS=NF*RCS;
NFT=P*GT*GR*NF*B;
NFPFA=GT*GR*F;
NFPD=P*GR*F*NF*L;
NFN=P*GT*GR*F*L*B*RCS;
LB=L*B;
LRCS=L*RCS;
LT=P*GT*GR*L*B;
LPFA=GT*GR*F*NF*L;
```

```
LPD=P*GR*F;
LN=P*GT*GR*F*NF*B*RCS;
BRCS=B*RCS;
BT=P*GT*GR;
BPFA=GT*GR*F*NF*B;
BPD=P*GR*F*L*B;
BN=P*GT*GR*F*NF*L*RCS;
RCST=P*GT*GR*B*RCS;
RCSPFA=GT*GR*F*NF*RCS;
RCSPD=P*GR*F*L*RCS;
RCSN=P*GT*GR*F*NF*L*B;
TPFA=P*F*NF*B;
TPD=GT*F*L*B;
TN=F*NF*L*RCS;
PFAPD=P*GT*NF*L;
PFAN=P*L*B*RCS;
PDN=GT*NF*B*RCS;

PROC PRINT DATA=NEW;
VAR P GT GR F NF L B RCS T PFA PD N PGT PGR PF PNF PL PB PRCS PT PPFA PPD PN
GTGR GTF GTNF GTL GTB GTRCS GTT GTPFA GTPD GTN GRF GRNF GRL GRB GRRCS GRT
GRPFA GRPD GRN FNF FL FB FRCS FT FPFA FPD FN NFL NFB NFRCS NFT NFPFA NFPD NFN
LB LRCS LT LPFA LPD LN BRCS BT BPFA BPD BN RCST RCSPFA RCSPD RCSN TPFA TPD TN
PFAPD PFAN PDN RANGE;

PROC REG DATA=NEW;
 MODEL RANGE= P GT GR F NF L B RCS T PFA PD N PGT PGR PF PNF PL PB PRCS
PT PPFA PPD PN GTGR GTF GTNF GTL GTB GTRCS GTT GTPFA GTPD GTN GRF GRNF GRL GRB
GRRCS GRT GRPFA GRPD GRN FNF FL FB FRCS FT FPFA FPD FN NFL
NFB NFRCS NFT NFPFA NFPD NFN LB LRCS LT LPFA LPD LN BRCS BT BPFA BPD
BN RCST RCSPFA RCSPD RCSN TPFA TPD TN PFAPD PFAN PDN/P;
 OUTPUT OUT=Z R=RESIDUAL;

PROC PLOT DATA=Z;
 PLOT RESIDUAL*RANGE='*';
 TITLE 'RADAR RANGE RESIDUALS';

PROC STEPWISE DATA=NEW;
  model RANGE= P GT GR F NF L B RCS T PFA PD N PGT PGR PF PNF PL PB PRCS
PT PPFA PPD PN GTGR GTF GTNF GTL GTB GTRCS GTT GTPFA GTPD GTN GRF GRNF GRL GRB
GRRCS GRT GRPFA GRPD GRN FNF FL FB FRCS FT FPFA FPD FN NFL
NFB NFRCS NFT NFPFA NFPD NFN LB LRCS LT LPFA LPD LN BRCS BT BPFA BPD
BN RCST RCSPFA RCSPD RCSN TPFA TPD TN PFAPD PFAN PDN/stepwise;
```

APPENDIX E:
SAS OUTPUT FOR RADAR A USING DESIGN 3

DEP VARIABLE: RANGE

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	66	51.62279018	0.78216349	999999.990	0.0001
ERROR	61	.00001875697	3.07491E-07		
C TOTAL	127	51.62280893			

ROOT MSE	0.000554519	R-SQUARE	1.0000
DEP MEAN	5.34712	ADJ R-SQ	1.0000
C.V.	0.01037043		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	5.34711959	.00004901302	99999.999	0.0001
P	1	0.03360575	.00004901302	685.649	0.0001
G	1	0.54000002	.00004901302	11017.481	0.0001
F	1	-0.0837262	.00004901302	-1708.245	0.0001
NF	1	-0.025	.00004901302	-510.069	0.0001
L	1	-0.012	.00004901302	-244.833	0.0001
B	1	-0.0336057	.00004901302	-685.647	0.0001
RCS	1	0.09726893	.00004901302	1984.553	0.0001
T	1	-0.00511969	.00004901302	-104.456	0.0001
PFA	1	0.13710156	.00004901302	2797.248	0.0001
PD	1	-0.254273	.00004901302	-5187.875	0.0001
N	1	0.08941402	.00004901302	1824.291	0.0001
PG	1	7.26562E-08	.00004901302	0.001	0.9988
PF	1	3.04688E-08	.00004901302	0.001	0.9995
PNF	1	-7.81250E-10	.00004901302	-0.000	1.0000
PL	1	2.34375E-09	.00004901302	0.000	1.0000
PB	1	3.90625E-09	.00004901302	0.000	0.9999
PRCS	1	-5.46875E-09	.00004901302	-0.000	0.9999
PT	1	-1.64063E-08	.00004901302	-0.000	0.9997
PPFA	1	7.81250E-10	.00004901302	0.000	1.0000
PPD	1	1.01563E-08	.00004901302	0.000	0.9998
PN	1	1.64062E-08	.00004901302	0.000	0.9997
GF	1	-1.48438E-08	.00004901302	-0.000	0.9998
GNF	1	1.64062E-08	.00004901302	0.000	0.9997
GL	1	-1.79688E-08	.00004901302	-0.000	0.9997
GB	1	-7.03125E-09	.00004901302	-0.000	0.9999
GRCS	1	-2.26563E-08	.00004901302	-0.000	0.9996
GT	1	-1.48438E-08	.00004901302	-0.000	0.9998
GPFA	1	-7.81250E-10	.00004901302	-0.000	1.0000
GPD	1	8.59375E-09	.00004901302	0.000	0.9999
GN	1	-7.81250E-10	.00004901302	-0.000	1.0000
FNF	1	-1.95313E-08	.00004901302	-0.000	0.9997

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
FL	1	1.17188E-08	.00004901302	0.000	0.9998
FB	1	1.64063E-08	.00004901302	0.000	0.9997
FRCS	1	-3.35937E-08	.00004901302	-0.001	0.9995
FT	1	-7.03125E-09	.00004901302	-0.000	0.9999
FPFA	1	1.01563E-08	.00004901302	0.000	0.9998
FPD	1	-1.48437E-08	.00004901302	-0.000	0.9998
FN	1	1.01562E-08	.00004901302	0.000	0.9998
NFL	1	8.59375E-09	.00004901302	0.000	0.9999
NFB	1	-1.17187E-08	.00004901302	-0.000	0.9998
NFRCS	1	7.81250E-10	.00004901302	0.000	1.0000
NFT	1	-3.90625E-09	.00004901302	-0.000	0.9999
NFPFA	1	1.95312E-08	.00004901302	0.000	0.9997
NFPD	1	7.81250E-10	.00004901302	0.000	1.0000
NFN	1	6.95313E-08	.00004901302	0.001	0.9989
LB	1	2.57812E-08	.00004901302	0.001	0.9996
LRCS	1	3.90625E-09	.00004901302	0.000	0.9999
LT	1	-7.03125E-09	.00004901302	-0.000	0.9999
LPFA	1	-8.59375E-09	.00004901302	-0.000	0.9999
LPD	1	7.81250E-10	.00004901302	0.000	1.0000
LN	1	-8.59375E-09	.00004901302	-0.000	0.9999
BRCS	1	-7.03125E-09	.00004901302	-0.000	0.9999
BT	1	-1.48438E-08	.00004901302	-0.000	0.9998
BPFA	1	-7.81250E-10	.00004901302	-0.000	1.0000
BPD	1	-1.01562E-08	.00004901302	-0.000	0.9998
BN	1	-7.81250E-10	.00004901302	-0.000	1.0000
RCST	1	4.14062E-08	.00004901302	0.001	0.9993
RCSPFA	1	-7.81250E-10	.00004901302	-0.000	1.0000
RCSPD	1	-7.03125E-09	.00004901302	-0.000	0.9999
RCSN	1	2.34375E-09	.00004901302	0.000	1.0000
TPFA	1	1.01562E-08	.00004901302	0.000	0.9998
TPD	1	1.32812E-08	.00004901302	0.000	0.9998
TN	1	4.14062E-08	.00004901302	0.001	0.9993
PFAPD	1	-0.0238046	.00004901302	-485.680	0.0001
PFAN	1	-0.0120859	.00004901302	-246.585	0.0001
PDN	1	0.004289062	.00004901302	87.509	0.0001

RESIDUAL CALCULATIONS

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
1	4.6025	4.6029	-3.8E-04
2	5.3907	5.3911	-3.8E-04
3	5.6535	5.6539	-3.8E-04
4	5.9684	5.9688	-3.8E-04
5	4.8592	4.8588	3.8E-04
6	4.2522	4.2519	3.8E-04
7	6.0805	6.0801	3.8E-04
8	5.7565	5.7561	3.8E-04
9	4.9664	4.9660	3.8E-04
10	4.3799	4.3795	3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
11	6.2082	6.2078	3.8E-04
12	5.8637	5.8633	3.8E-04
13	4.3953	4.3957	-3.8E-04
14	5.1631	5.1634	-3.8E-04
15	5.4258	5.4262	-3.8E-04
16	5.7612	5.7616	-3.8E-04
17	4.5393	4.5397	-3.8E-04
18	4.8747	4.8751	-3.8E-04
19	5.6687	5.6691	-3.8E-04
20	6.4365	6.4369	-3.8E-04
21	4.9868	4.9864	3.8E-04
22	4.6422	4.6419	3.8E-04
23	5.9050	5.9046	3.8E-04
24	5.3185	5.3181	3.8E-04
25	5.0940	5.0936	3.8E-04
26	4.7699	4.7695	3.8E-04
27	6.0327	6.0323	3.8E-04
28	5.4257	5.4253	3.8E-04
29	4.3321	4.3325	-3.8E-04
30	4.6470	4.6474	-3.8E-04
31	5.4410	5.4414	-3.8E-04
32	6.2293	6.2297	-3.8E-04
33	5.2461	5.2465	-3.8E-04
34	4.6127	4.6131	-3.8E-04
35	5.8443	5.8446	-3.8E-04
36	5.6433	5.6437	-3.8E-04
37	4.1281	4.1277	3.8E-04
38	4.8490	4.8486	3.8E-04
39	5.6118	5.6114	3.8E-04
40	6.0908	6.0904	3.8E-04
41	4.2353	4.2349	3.8E-04
42	4.9767	4.9763	3.8E-04
43	5.7395	5.7391	3.8E-04
44	6.1980	6.1976	3.8E-04
45	5.0389	5.0393	-3.8E-04
46	4.3850	4.3854	-3.8E-04
47	5.6166	5.6169	-3.8E-04
48	5.4361	5.4365	-3.8E-04
49	4.7300	4.7304	-3.8E-04
50	4.5495	4.5499	-3.8E-04
51	6.3123	6.3127	-3.8E-04
52	5.6585	5.6589	-3.8E-04
53	4.5181	4.5177	3.8E-04
54	4.9765	4.9761	3.8E-04
55	5.1738	5.1734	3.8E-04
56	5.9152	5.9148	3.8E-04
57	4.6253	4.6249	3.8E-04
58	5.1042	5.1038	3.8E-04
59	5.3015	5.3011	3.8E-04
60	6.0224	6.0220	3.8E-04
61	4.5228	4.5232	-3.8E-04

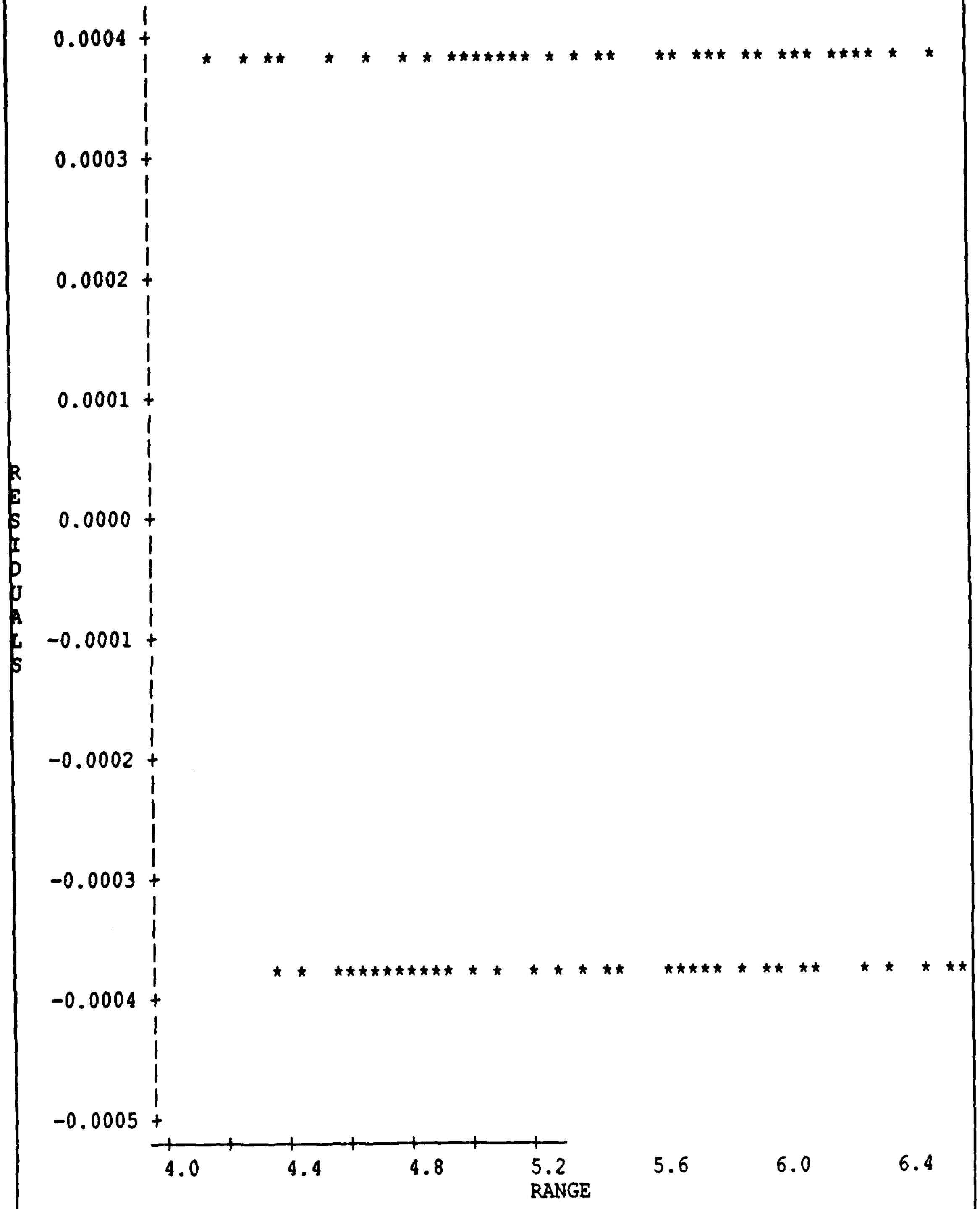
OBS	ACTUAL	PREDICT VALUE	RESIDUAL
62	4.3218	4.3222	-3.8E-04
63	6.0846	6.0850	-3.8E-04
64	5.4513	5.4517	-3.8E-04
65	4.9713	4.9709	3.8E-04
66	5.4297	5.4293	3.8E-04
67	5.6270	5.6266	3.8E-04
68	6.3684	6.3680	3.8E-04
69	4.8483	4.8487	-3.8E-04
70	4.6678	4.6682	-3.8E-04
71	6.4306	6.4310	-3.8E-04
72	5.7768	5.7772	-3.8E-04
73	4.9760	4.9764	-3.8E-04
74	4.7750	4.7754	-3.8E-04
75	6.5378	6.5382	-3.8E-04
76	5.9045	5.9049	-3.8E-04
77	4.7436	4.7432	3.8E-04
78	5.2225	5.2221	3.8E-04
79	5.4198	5.4194	3.8E-04
80	6.1407	6.1403	3.8E-04
81	4.5333	4.5329	3.8E-04
82	5.2542	5.2538	3.8E-04
83	6.0170	6.0166	3.8E-04
84	6.4960	6.4956	3.8E-04
85	5.3164	5.3168	-3.8E-04
86	4.6830	4.6834	-3.8E-04
87	5.9146	5.9149	-3.8E-04
88	5.7136	5.7140	-3.8E-04
89	5.4441	5.4445	-3.8E-04
90	4.7902	4.7906	-3.8E-04
91	6.0218	6.0222	-3.8E-04
92	5.8413	5.8417	-3.8E-04
93	4.3056	4.3052	3.8E-04
94	5.0470	5.0466	3.8E-04
95	5.8098	5.8094	3.8E-04
96	6.2683	6.2679	3.8E-04
97	5.3055	5.3052	3.8E-04
98	4.9610	4.9606	3.8E-04
99	6.2237	6.2234	3.8E-04
100	5.6373	5.6369	3.8E-04
101	4.5232	4.5235	-3.8E-04
102	4.8586	4.8589	-3.8E-04
103	5.6526	5.6530	-3.8E-04
104	6.4204	6.4208	-3.8E-04
105	4.6509	4.6512	-3.8E-04
106	4.9658	4.9662	-3.8E-04
107	5.7598	5.7602	-3.8E-04
108	6.5481	6.5485	-3.8E-04
109	5.0779	5.0775	3.8E-04
110	4.7538	4.7534	3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
111	6.0165	6.0161	3.8E-04
112	5.4096	5.4092	3.8E-04
113	5.1300	5.1296	3.8E-04
114	4.5230	4.5226	3.8E-04
115	6.3513	6.3509	3.8E-04
116	6.0273	6.0269	3.8E-04
117	4.5384	4.5387	-3.8E-04
118	5.3266	5.3270	-3.8E-04
119	5.5894	5.5898	-3.8E-04
120	5.9043	5.9047	-3.8E-04
121	4.6660	4.6664	-3.8E-04
122	5.4338	5.4342	-3.8E-04
123	5.6966	5.6970	-3.8E-04
124	6.0320	6.0324	-3.8E-04
125	4.9023	4.9019	3.8E-04
126	4.3158	4.3154	3.8E-04
127	6.1441	6.1437	3.8E-04
128	5.7996	5.7992	3.8E-04

SUM OF RESIDUALS 1.65423E-14
SUM OF SQUARED RESIDUALS .00001875697

RADAR RANGE RESIDUALS

PLOT OF RESIDUAL*RANGE   SYMBOL USED IS *



NOTE: 59 OBS HIDDEN   RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

NOTE: SLENTRY AND SLSTAY HAVE BEEN SET TO .15 FOR THE STEPWISE TECHNIQUE.

STEP 1 VARIABLE G ENTERED R SQUARE = 0.72302928
C(P) = 46498764.7519

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	1	37.32480227	37.32480227	328.92	0.0001
ERROR	126	14.29800667	0.11347624		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
G	0.54000002	0.02977471	37.32480227	328.92	0.0001

BOUNDS ON CONDITION NUMBER: 1, 1

STEP 2 VARIABLE PD ENTERED R SQUARE = 0.88334285
C(P) = 19584720.6672

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	45.60063897	22.80031949	473.26	0.0001
ERROR	125	6.02216996	0.04817736		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
G	0.54000002	0.01940066	37.32480227	774.74	0.0001
PD	-0.25427342	0.01940066	8.27583671	171.78	0.0001

BOUNDS ON CONDITION NUMBER: 1, 4

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 3 VARIABLE PFA ENTERED R SQUARE = 0.92995006
C(P) = 11760128.1255

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	48.00663421	16.00221140	548.72	0.0001
ERROR	124	3.61617472	0.02916270		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
G	0.54000002	0.01509416	37.32480227	1279.88	0.0001
PFA	0.13710156	0.01509416	2.40599524	82.50	0.0001
PD	-0.25427342	0.01509416	8.27583671	283.78	0.0001

BOUNDS ON CONDITION NUMBER: 1, 9

STEP 4 VARIABLE RCS ENTERED R SQUARE = 0.95340944
C(P) = 7821680.56534

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	49.21767343	12.30441836	629.25	0.0001
ERROR	123	2.40513550	0.01955395		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
G	0.54000002	0.01235982	37.32480227	1908.81	0.0001
RCS	0.09726893	0.01235982	1.21103922	61.93	0.0001
PFA	0.13710156	0.01235982	2.40599524	123.04	0.0001
PD	-0.25427342	0.01235982	8.27583671	423.23	0.0001

BOUNDS ON CONDITION NUMBER: 1, 16

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 5 VARIABLE N ENTERED R SQUARE = 0.97323291
C(P) = 4493644.72613

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	50.24101632	10.04820326	887.17	0.0001
ERROR	122	1.38179261	0.01132617		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
G	0.54000002	0.00940668	37.32480227	3295.45	0.0001
RCS	0.09726893	0.00940668	1.21103922	106.92	0.0001
PFA	0.13710156	0.00940668	2.40599524	212.43	0.0001
PD	-0.25427342	0.00940668	8.27583671	730.68	0.0001
N	0.08941402	0.00940668	1.02334289	90.35	0.0001

BOUNDS ON CONDITION NUMBER: 1, 25

STEP 6 VARIABLE F ENTERED R SQUARE = 0.99061458
C(P) = 1575546.26249

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	6	51.13830701	8.52305117	2128.56	0.0001
ERROR	121	0.48450192	0.00400415		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
G	0.54000002	0.00559307	37.32480227	9321.53	0.0001
F	-0.08372624	0.00559307	0.89729069	224.09	0.0001
RCS	0.09726893	0.00559307	1.21103922	302.45	0.0001
PFA	0.13710156	0.00559307	2.40599524	600.88	0.0001
PD	-0.25427342	0.00559307	8.27583671	2066.82	0.0001
N	0.08941402	0.00559307	1.02334289	255.57	0.0001

BOUNDS ON CONDITION NUMBER: 1, 36

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 7 VARIABLE P ENTERED R SQUARE = 0.99341482
C(P) = 1105433.23692

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	7	51.28286332	7.32612333	2586.10	0.0001
ERROR	120	0.33994561	0.00283288		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
P	0.03360575	0.00470445	0.14455631	51.03	0.0001
G	0.54000002	0.00470445	37.32480227	13175.57	0.0001
F	-0.08372624	0.00470445	0.89729069	316.74	0.0001
RCS	0.09726893	0.00470445	1.21103922	427.49	0.0001
PFA	0.13710156	0.00470445	2.40599524	849.31	0.0001
PD	-0.25427342	0.00470445	8.27583671	2921.35	0.0001
N	0.08941402	0.00470445	1.02334289	361.24	0.0001

BOUNDS ON CONDITION NUMBER: 1, 49

STEP 8 VARIABLE B ENTERED R SQUARE = 0.99621504
C(P) = 635322.746886

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	8	51.42741885	6.42842736	3915.16	0.0001
ERROR	119	0.19539008	0.00164193		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
P	0.03360575	0.00358156	0.14455631	88.04	0.0001
G	0.54000002	0.00358156	37.32480227	22732.23	0.0001
F	-0.08372624	0.00358156	0.89729069	546.48	0.0001
B	-0.03360566	0.00358156	0.14455553	88.04	0.0001
RCS	0.09726893	0.00358156	1.21103922	737.57	0.0001
PFA	0.13710156	0.00358156	2.40599524	1465.34	0.0001
PD	-0.25427342	0.00358156	8.27583671	5040.30	0.0001
N	0.08941402	0.00358156	1.02334289	623.25	0.0001

BOUNDS ON CONDITION NUMBER: 1, 64

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 9 VARIABLE NF ENTERED R SQUARE = 0.99776475
C(P) = 375154.625999

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	9	51.50741892	5.72304655	5852.49	0.0001
ERROR	118	0.11539002	0.00097788		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
P	0.03360575	0.00276400	0.14455631	147.83	0.0001
G	0.54000002	0.00276400	37.32480227	38169.04	0.0001
F	-0.08372624	0.00276400	0.89729069	917.59	0.0001
NF	-0.02500001	0.00276400	0.08000007	81.81	0.0001
B	-0.03360566	0.00276400	0.14455553	147.83	0.0001
RCS	0.09726893	0.00276400	1.21103922	1238.43	0.0001
PFA	0.13710156	0.00276400	2.40599524	2460.42	0.0001
PD	-0.25427342	0.00276400	8.27583671	8463.03	0.0001
N	0.08941402	0.00276400	1.02334289	1046.49	0.0001

BOUNDS ON CONDITION NUMBER: 1, 81

STEP 10 VARIABLE PFAPD ENTERED R SQUARE = 0.99916980
C(P) = 139271.496176

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	10	51.57995156	5.15799516	14081.25	0.0001
ERROR	117	0.04285738	0.00036630		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
P	0.03360575	0.00169167	0.14455631	394.64	0.0001
G	0.54000002	0.00169167	37.32480227	101896.16	0.0001
F	-0.08372624	0.00169167	0.89729069	2449.59	0.0001
NF	-0.02500001	0.00169167	0.08000007	218.40	0.0001
B	-0.03360566	0.00169167	0.14455553	394.63	0.0001
RCS	0.09726893	0.00169167	1.21103922	3306.12	0.0001
PFA	0.13710156	0.00169167	2.40599524	6568.33	0.0001
PD	-0.25427342	0.00169167	8.27583671	22592.91	0.0001
N	0.08941402	0.00169167	1.02334289	2793.71	0.0001
PFAPD	-0.02380465	0.00169167	0.07253264	198.01	0.0001

BOUNDS ON CONDITION NUMBER: 1, 100

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 11 VARIABLE PFAN ENTERED R SQUARE = 0.99953198
C(P) = 78469.1464066

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	11	51.59864837	4.69078622	22521.46	0.0001
ERROR	116	0.02416056	0.00020828		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
P	0.03360575	0.00127561	0.14455631	694.05	0.0001
G	0.54000002	0.00127561	37.32480227	179204.31	0.0001
F	-0.08372624	0.00127561	0.89729069	4308.08	0.0001
NF	-0.02500001	0.00127561	0.08000007	384.10	0.0001
B	-0.03360566	0.00127561	0.14455553	694.04	0.0001
RCS	0.09726893	0.00127561	1.21103922	5814.46	0.0001
PFA	0.13710156	0.00127561	2.40599524	11551.69	0.0001
PD	-0.25427342	0.00127561	8.27583671	39734.05	0.0001
N	0.08941402	0.00127561	1.02334289	4913.29	0.0001
PFAPD	-0.02380465	0.00127561	0.07253264	348.24	0.0001
PFAN	-0.01208589	0.00127561	0.01869681	89.77	0.0001

BOUNDS ON CONDITION NUMBER: 1, 121

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 12 VARIABLE L ENTERED R SQUARE = 0.99988903
C(P) = 18527.7729100

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	12	51.61708044	4.30142337	86351.43	0.0001
ERROR	115	0.00572849	0.00004981		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
P	0.03360575	0.00062383	0.14455631	2901.98	0.0001
G	0.54000002	0.00062383	37.32480227	749298.52	0.0001
F	-0.08372624	0.00062383	0.89729069	18013.19	0.0001
NF	-0.02500001	0.00062383	0.08000007	1606.01	0.0001
L	-0.01200002	0.00062383	0.01843207	370.03	0.0001
B	-0.03360566	0.00062383	0.14455553	2901.96	0.0001
RCS	0.09726893	0.00062383	1.21103922	24311.71	0.0001
PFA	0.13710156	0.00062383	2.40599524	48300.56	0.0001
PD	-0.25427342	0.00062383	8.27583671	166138.11	0.0001
N	0.08941402	0.00062383	1.02334289	20543.69	0.0001
PFAPD	-0.02380465	0.00062383	0.07253264	1456.10	0.0001
PFAN	-0.01208589	0.00062383	0.01869681	375.34	0.0001

BOUNDS ON CONDITION NUMBER: 1, 144

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 13 VARIABLE T ENTERED R SQUARE = 0.99995402
C(P) = 7618.75804859

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	13	51.62043548	3.97080273	190722.89	0.0001
ERROR	114	0.00237345	0.00002082		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
P	0.03360575	0.00040330	0.14455631	6943.23	0.0001
G	0.54000002	0.00040330	37.32480227	999999.99	0.0001
F	-0.08372624	0.00040330	0.89729069	43098.05	0.0001
NF	-0.02500001	0.00040330	0.08000007	3842.51	0.0001
L	-0.01200002	0.00040330	0.01843207	885.32	0.0001
B	-0.03360566	0.00040330	0.14455553	6943.19	0.0001
RCS	0.09726893	0.00040330	1.21103922	58167.81	0.0001
T	-0.00511969	0.00040330	0.00335504	161.15	0.0001
PFA	0.13710156	0.00040330	2.40599524	115563.12	0.0001
PD	-0.25427342	0.00040330	8.27583671	397499.34	0.0001
N	0.08941402	0.00040330	1.02334289	49152.51	0.0001
PFAPD	-0.02380465	0.00040330	0.07253264	3483.84	0.0001
PFAN	-0.01208589	0.00040330	0.01869681	898.03	0.0001

BOUNDS ON CONDITION NUMBER: 1, 169

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 14 VARIABLE PDN ENTERED R SQUARE = 0.99999964
C(P) = -36.99999108

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	14	51.62279018	3.68734216	999999.99	0.0001
ERROR	113	0.00001876	0.00000017		
TOTAL	127	51.62280893			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.34711959				
P	0.03360575	0.00003601	0.14455631	870868.69	0.0001
G	0.54000002	0.00003601	37.32480227	999999.99	0.0001
F	-0.08372624	0.00003601	0.89729069	999999.99	0.0001
NF	-0.02500001	0.00003601	0.08000007	481954.42	0.0001
L	-0.01200002	0.00003601	0.01843207	111042.63	0.0001
B	-0.03360566	0.00003601	0.14455553	870863.99	0.0001
RCS	0.09726893	0.00003601	1.21103922	999999.99	0.0001
T	-0.00511969	0.00003601	0.00335504	20212.20	0.0001
PFA	0.13710156	0.00003601	2.40599524	999999.99	0.0001
PD	-0.25427342	0.00003601	8.27583671	999999.99	0.0001
N	0.08941402	0.00003601	1.02334289	999999.99	0.0001
PFAPD	-0.02380465	0.00003601	0.07253264	436967.47	0.0001
PFAN	-0.01208589	0.00003601	0.01869681	112637.55	0.0001
PDN	0.00428906	0.00003601	0.00235469	14185.68	0.0001

BOUNDS ON CONDITION NUMBER: 1, 196

NO OTHER VARIABLES MET THE 0.1500 SIGNIFICANCE LEVEL FOR ENTRY INTO THE MODEL.

RADAR RANGE RESIDUALS

SUMMARY OF STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

	VARIABLE		NUMBER	PARTIAL	MODEL	
STEP	ENTERED	REMOVED	IN	R**2	R**2	C(P)
1	G		1	0.7230	0.7230	4.650E+07
2	PD		2	0.1603	0.8833	1.958E+07
3	PFA		3	0.0466	0.9300	1.176E+07
4	RCS		4	0.0235	0.9534	7.822E+06
5	N		5	0.0198	0.9732	4.494E+06
6	F		6	0.0174	0.9906	1.576E+06
7	P		7	0.0028	0.9934	1.105E+06
8	B		8	0.0028	0.9962	6.353E+05
9	NF		9	0.0015	0.9978	3.752E+05
10	PFAPD		10	0.0014	0.9992	1.393E+05
11	PFAN		11	0.0004	0.9995	7.847E+04
12	L		12	0.0004	0.9999	1.853E+04
13	T		13	0.0001	1.0000	7.619E+03
14	PDN		14	0.0000	1.0000	-3.70E+01

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F	PROB>F
1	G		328.9217	0.0001
2	PD		171.7785	0.0001
3	PFA		82.5025	0.0001
4	RCS		61.9332	0.0001
5	N		90.3521	0.0001
6	F		224.0903	0.0001
7	P		51.0280	0.0001
8	B		88.0398	0.0001
9	NF		81.8096	0.0001
10	PFAPD		198.0130	0.0001
11	PFAN		89.7674	0.0001
12	L		370.0253	0.0001
13	T		161.1471	0.0001
14	PDN		9999.9999	0.0001

APPENDIX F:

SAS OUTPUT FOR RADAR B USING DESIGN 3

DEP VARIABLE: RANGE

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	66	49.98259038	0.75731198	999999.990	0.0001
ERROR	61	.00001875889	3.07523E-07		
C TOTAL	127	49.98260914			

ROOT MSE	0.0005545473	R-SQUARE	1.0000
DEP MEAN	4.905378	ADJ R-SQ	1.0000
C.V.	0.01130489		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	4.90537758	.00004901552	99999.999	0.0001
P	1	0.02201136	.00004901552	449.069	0.0001
G	1	0.52500008	.00004901552	10710.895	0.0001
F	1	-0.0738483	.00004901552	-1506.630	0.0001
NF	1	-0.075	.00004901552	-1530.128	0.0001
L	1	-0.0225	.00004901552	-459.039	0.0001
B	1	-0.0336057	.00004901552	-685.614	0.0001
RCS	1	0.09726889	.00004901552	1984.451	0.0001
T	1	-0.0051197	.00004901552	-104.451	0.0001
PFA	1	0.13710155	.00004901552	2797.105	0.0001
PD	1	-0.254273	.00004901552	-5187.610	0.0001
N	1	0.08941405	.00004901552	1824.199	0.0001
PG	1	-2.81250E-08	.00004901552	-0.001	0.9995
PF	1	2.34375E-08	.00004901552	0.000	0.9996
PNF	1	-3.12500E-09	.00004901552	-0.000	0.9999
PL	1	1.25000E-08	.00004901552	0.000	0.9998
PB	1	4.68750E-09	.00004901552	0.000	0.9999
PRCS	1	-1.09375E-08	.00004901552	-0.000	0.9998
PT	1	-1.09375E-08	.00004901552	-0.000	0.9998
PPFA	1	2.34375E-08	.00004901552	0.000	0.9996
PPD	1	-1.56250E-09	.00004901552	-0.000	1.0000
PN	1	-1.25000E-08	.00004901552	-0.000	0.9998
GF	1	1.56250E-08	.00004901552	0.000	0.9997
GNF	1	-7.81250E-09	.00004901552	-0.000	0.9999
GL	1	4.68750E-09	.00004901552	0.000	0.9999
GB	1	-2.81250E-08	.00004901552	-0.001	0.9995
GRCS	1	9.37500E-09	.00004901552	0.000	0.9998
GT	1	1.73472E-18	.00004901552	0.000	1.0000
GPFA	1	9.54098E-18	.00004901552	0.000	1.0000
GPD	1	1.56250E-08	.00004901552	0.000	0.9997
GN	1	-4.68750E-09	.00004901552	-0.000	0.9999
FNF	1	1.56250E-08	.00004901552	0.000	0.9997

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
FL	1	9.37500E-09	.00004901552	0.000	0.9998
FB	1	2.03125E-08	.00004901552	0.000	0.9997
FRCS	1	-1.71875E-08	.00004901552	-0.000	0.9997
FT	1	4.68750E-09	.00004901552	0.000	0.9999
FPFA	1	-1.71875E-08	.00004901552	-0.000	0.9997
FPD	1	-1.56250E-09	.00004901552	-0.000	1.0000
FN	1	4.33681E-18	.00004901552	0.000	1.0000
NFL	1	-4.68750E-09	.00004901552	-0.000	0.9999
NFB	1	6.07153E-18	.00004901552	0.000	1.0000
NFRCS	1	-2.86229E-17	.00004901552	-0.000	1.0000
NFT	1	-1.73472E-18	.00004901552	-0.000	1.0000
NFPFA	1	1.56250E-08	.00004901552	0.000	0.9997
NFPD	1	-3.12500E-09	.00004901552	-0.000	0.9999
NFN	1	1.71875E-08	.00004901552	0.000	0.9997
LB	1	9.37500E-09	.00004901552	0.000	0.9998
LRCS	1	2.50000E-08	.00004901552	0.001	0.9996
LT	1	-6.25000E-09	.00004901552	-0.000	0.9999
LPFA	1	-1.25000E-08	.00004901552	-0.000	0.9998
LPD	1	-6.25000E-09	.00004901552	-0.000	0.9999
LN	1	2.96875E-08	.00004901552	0.001	0.9995
BRCS	1	1.40625E-08	.00004901552	0.000	0.9998
BT	1	-4.68750E-09	.00004901552	-0.000	0.9999
BPFA	1	-1.09375E-08	.00004901552	-0.000	0.9998
BPD	1	-1.56250E-09	.00004901552	-0.000	1.0000
BN	1	1.56250E-08	.00004901552	0.000	0.9997
RCST	1	1.71875E-08	.00004901552	0.000	0.9997
RCSPFA	1	4.68750E-09	.00004901552	0.000	0.9999
RCSPD	1	3.28125E-08	.00004901552	0.001	0.9995
RCSN	1	-2.81250E-08	.00004901552	-0.001	0.9995
TPFA	1	4.68750E-09	.00004901552	0.000	0.9999
TPD	1	-1.56250E-09	.00004901552	-0.000	1.0000
TN	1	-1.25000E-08	.00004901552	-0.000	0.9998
PFAPD	1	-0.0238047	.00004901552	-485.656	0.0001
PFAN	1	-0.0120859	.00004901552	-246.573	0.0001
PDN	1	0.004289053	.00004901552	87.504	0.0001

RESIDUAL CALCULATIONS

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
1	4.2380	4.2383	-3.8E-04
2	5.0030	5.0034	-3.8E-04
3	5.2590	5.2594	-3.8E-04
4	5.5507	5.5511	-3.8E-04
5	4.5144	4.5141	3.8E-04
6	3.8843	3.8839	3.8E-04
7	5.7058	5.7054	3.8E-04
8	5.3585	5.3581	3.8E-04
9	4.5019	4.5015	3.8E-04
10	3.8922	3.8918	3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
11	5.7137	5.7133	3.8E-04
12	5.3460	5.3456	3.8E-04
13	3.9505	3.9509	-3.8E-04
14	4.6951	4.6955	-3.8E-04
15	4.9511	4.9515	-3.8E-04
16	5.2633	5.2637	-3.8E-04
17	4.1538	4.1542	-3.8E-04
18	4.4660	4.4663	-3.8E-04
19	5.2532	5.2536	-3.8E-04
20	5.9978	5.9982	-3.8E-04
21	4.6210	4.6206	3.8E-04
22	4.2533	4.2529	3.8E-04
23	5.5092	5.5088	3.8E-04
24	4.8995	4.8991	3.8E-04
25	4.6085	4.6081	3.8E-04
26	4.2612	4.2608	3.8E-04
27	5.5171	5.5167	3.8E-04
28	4.8870	4.8866	3.8E-04
29	3.8663	3.8667	-3.8E-04
30	4.1580	4.1584	-3.8E-04
31	4.9453	4.9456	-3.8E-04
32	5.7103	5.7107	-3.8E-04
33	4.8816	4.8819	-3.8E-04
34	4.2250	4.2254	-3.8E-04
35	5.4497	5.4501	-3.8E-04
36	5.2256	5.2260	-3.8E-04
37	3.7833	3.7829	3.8E-04
38	4.4810	4.4806	3.8E-04
39	5.2370	5.2367	3.8E-04
40	5.6928	5.6924	3.8E-04
41	3.7707	3.7704	3.8E-04
42	4.4889	4.4886	3.8E-04
43	5.2450	5.2446	3.8E-04
44	5.6803	5.6799	3.8E-04
45	4.5941	4.5945	-3.8E-04
46	3.9171	3.9175	-3.8E-04
47	5.1418	5.1422	-3.8E-04
48	4.9381	4.9385	-3.8E-04
49	4.3445	4.3449	-3.8E-04
50	4.1408	4.1412	-3.8E-04
51	5.8968	5.8972	-3.8E-04
52	5.2198	5.2201	-3.8E-04
53	4.1523	4.1519	3.8E-04
54	4.5876	4.5872	3.8E-04
55	4.7780	4.7777	3.8E-04
56	5.4962	5.4959	3.8E-04
57	4.1397	4.1394	3.8E-04
58	4.5955	4.5951	3.8E-04
59	4.7860	4.7856	3.8E-04
60	5.4837	5.4833	3.8E-04
61	4.0570	4.0574	-3.8E-04

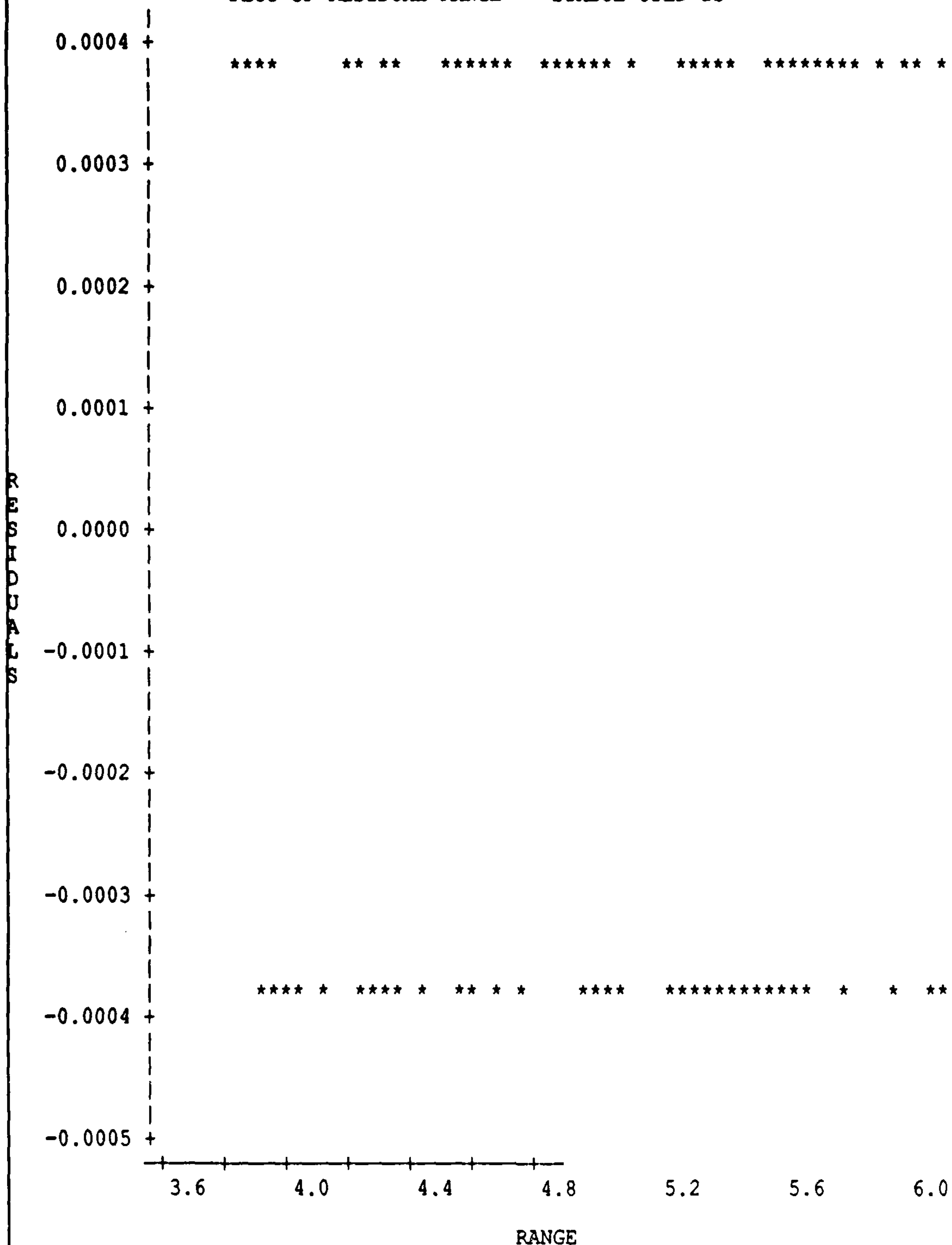
OBS	ACTUAL	PREDICT VALUE	RESIDUAL
62	3.8329	3.8333	-3.8E-04
63	5.5889	5.5892	-3.8E-04
64	4.9323	4.9327	-3.8E-04
65	4.6067	4.6063	3.8E-04
66	5.0420	5.0416	3.8E-04
67	5.2325	5.2321	3.8E-04
68	5.9507	5.9503	3.8E-04
69	4.5035	4.5039	-3.8E-04
70	4.2999	4.3003	-3.8E-04
71	6.0558	6.0562	-3.8E-04
72	5.3788	5.3792	-3.8E-04
73	4.5115	4.5119	-3.8E-04
74	4.2873	4.2877	-3.8E-04
75	6.0433	6.0437	-3.8E-04
76	5.3868	5.3871	-3.8E-04
77	4.2988	4.2984	3.8E-04
78	4.7546	4.7542	3.8E-04
79	4.9450	4.9447	3.8E-04
80	5.6428	5.6424	3.8E-04
81	4.1477	4.1473	3.8E-04
82	4.8455	4.8451	3.8E-04
83	5.6015	5.6011	3.8E-04
84	6.0573	6.0569	3.8E-04
85	4.9506	4.9510	-3.8E-04
86	4.2941	4.2944	-3.8E-04
87	5.5188	5.5192	-3.8E-04
88	5.2946	5.2950	-3.8E-04
89	4.9585	4.9589	-3.8E-04
90	4.2815	4.2819	-3.8E-04
91	5.5062	5.5066	-3.8E-04
92	5.3026	5.3030	-3.8E-04
93	3.8398	3.8394	3.8E-04
94	4.5580	4.5576	3.8E-04
95	5.3140	5.3137	3.8E-04
96	5.7493	5.7489	3.8E-04
97	4.9410	4.9406	3.8E-04
98	4.5733	4.5729	3.8E-04
99	5.8292	5.8288	3.8E-04
100	5.2195	5.2192	3.8E-04
101	4.1784	4.1788	-3.8E-04
102	4.4906	4.4910	-3.8E-04
103	5.2778	5.2782	-3.8E-04
104	6.0224	6.0228	-3.8E-04
105	4.1863	4.1867	-3.8E-04
106	4.4781	4.4784	-3.8E-04
107	5.2653	5.2657	-3.8E-04
108	6.0304	6.0307	-3.8E-04
109	4.6331	4.6327	3.8E-04
110	4.2858	4.2855	3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
111	5.5418	5.5414	3.8E-04
112	4.9116	4.9112	3.8E-04
113	4.7445	4.7441	3.8E-04
114	4.1143	4.1139	3.8E-04
115	5.9358	5.9354	3.8E-04
116	5.5885	5.5882	3.8E-04
117	4.1726	4.1730	-3.8E-04
118	4.9377	4.9380	-3.8E-04
119	5.1936	5.1940	-3.8E-04
120	5.4854	5.4857	-3.8E-04
121	4.1805	4.1809	-3.8E-04
122	4.9251	4.9255	-3.8E-04
123	5.1811	5.1815	-3.8E-04
124	5.4933	5.4937	-3.8E-04
125	4.4365	4.4361	3.8E-04
126	3.8268	3.8265	3.8E-04
127	5.6483	5.6479	3.8E-04
128	5.2806	5.2802	3.8E-04

SUM OF RESIDUALS -7.07212E-14
SUM OF SQUARED RESIDUALS .00001875889

RADAR RANGE RESIDUALS

PLOT OF RESIDUAL*RANGE SYMBOL USED IS *



NOTE: 56 OBS HIDDEN RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

NOTE: SLENTRY AND SLSTAY HAVE BEEN SET TO .15 FOR THE STEPWISE TECHNIQUE.

STEP 1 VARIABLE G ENTERED R SQUARE = 0.70584572
C(P) = 47809672.6311

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	1	35.28001071	35.28001071	302.35	0.0001
ERROR	126	14.70259843	0.11668729		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
G	0.52500008	0.03019304	35.28001071	302.35	0.0001

BOUNDS ON CONDITION NUMBER: 1, 1

STEP 2 VARIABLE PD ENTERED R SQUARE = 0.87142000
C(P) = 20898378.8579

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	43.55584543	21.77792272	423.58	0.0001
ERROR	125	6.42676371	0.05141411		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
G	0.52500008	0.02004177	35.28001071	686.19	0.0001
PD	-0.25427339	0.02004177	8.27583472	160.96	0.0001

BOUNDS ON CONDITION NUMBER: 1, 4

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 3 VARIABLE PFA ENTERED R SQUARE = 0.91955664
C(P) = 13074585.5421

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	45.96184020	15.32061340	472.49	0.0001
ERROR	124	4.02076894	0.03242556		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
G	0.52500008	0.01591618	35.28001071	1088.03	0.0001
PFA	0.13710155	0.01591618	2.40599477	74.20	0.0001
PD	-0.25427339	0.01591618	8.27583472	255.23	0.0001

BOUNDS ON CONDITION NUMBER: 1, 9

STEP 4 VARIABLE RCS ENTERED R SQUARE = 0.94378584
C(P) = 9136542.09690

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	47.17287863	11.79321966	516.27	0.0001
ERROR	123	2.80973051	0.02284334		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
G	0.52500008	0.01335903	35.28001071	1544.43	0.0001
RCS	0.09726889	0.01335903	1.21103842	53.01	0.0001
PFA	0.13710155	0.01335903	2.40599477	105.33	0.0001
PD	-0.25427339	0.01335903	8.27583472	362.29	0.0001

BOUNDS ON CONDITION NUMBER: 1, 16

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 5 VARIABLE N ENTERED R SQUARE = 0.96425983
C(P) = 5808842.69865

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	48.19622240	9.63924448	658.31	0.0001
ERROR	122	1.78638675	0.01464251		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
G	0.52500008	0.01069554	35.28001071	2409.42	0.0001
RCS	0.09726889	0.01069554	1.21103842	82.71	0.0001
PFA	0.13710155	0.01069554	2.40599477	164.32	0.0001
PD	-0.25427339	0.01069554	8.27583472	565.19	0.0001
N	0.08941405	0.01069554	1.02334377	69.89	0.0001

BOUNDS ON CONDITION NUMBER: 1, 25

STEP 6 VARIABLE NF ENTERED R SQUARE = 0.97866485
C(P) = 3467553.35190

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	6	48.91622267	8.15270378	925.07	0.0001
ERROR	121	1.06638648	0.00881311		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
G	0.52500008	0.00829774	35.28001071	4003.13	0.0001
NF	-0.07500001	0.00829774	0.72000027	81.70	0.0001
RCS	0.09726889	0.00829774	1.21103842	137.41	0.0001
PFA	0.13710155	0.00829774	2.40599477	273.00	0.0001
PD	-0.25427339	0.00829774	8.27583472	939.04	0.0001
N	0.08941405	0.00829774	1.02334377	116.12	0.0001

BOUNDS ON CONDITION NUMBER: 1, 36

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 7   VARIABLE F ENTERED   R SQUARE = 0.99263083
C(P) = 1197621.38563

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	7	49.61427892	7.08775413	2309.15	0.0001
ERROR	120	0.36833022	0.00306942		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
G	0.52500008	0.00489692	35.28001071	11494.04	0.0001
F	-0.07384825	0.00489692	0.69805625	227.42	0.0001
NF	-0.07500001	0.00489692	0.72000027	234.57	0.0001
RCS	0.09726889	0.00489692	1.21103842	394.55	0.0001
PFA	0.13710155	0.00489692	2.40599477	783.86	0.0001
PD	-0.25427339	0.00489692	8.27583472	2696.22	0.0001
N	0.08941405	0.00489692	1.02334377	333.40	0.0001

BOUNDS ON CONDITION NUMBER: 1, 49

STEP 8   VARIABLE B ENTERED   R SQUARE = 0.99552296
C(P) = 727557.402500

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	8	49.75883489	6.21985436	3307.63	0.0001
ERROR	119	0.22377425	0.00188046		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
G	0.52500008	0.00383289	35.28001071	18761.41	0.0001
F	-0.07384825	0.00383289	0.69805625	371.22	0.0001
NF	-0.07500001	0.00383289	0.72000027	382.89	0.0001
B	-0.03360571	0.00383289	0.14455597	76.87	0.0001
RCS	0.09726889	0.00383289	1.21103842	644.01	0.0001
PFA	0.13710155	0.00383289	2.40599477	1279.47	0.0001
PD	-0.25427339	0.00383289	8.27583472	4400.97	0.0001
N	0.08941405	0.00383289	1.02334377	544.20	0.0001

BOUNDS ON CONDITION NUMBER: 1, 64

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 9 VARIABLE PFAPD ENTERED R SQUARE = 0.99697412
C(P) = 491697.995835

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	9	49.83136763	5.53681863	4319.88	0.0001
ERROR	118	0.15124151	0.00128171		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
G	0.52500008	0.00316439	35.28001071	27525.78	0.0001
F	-0.07384825	0.00316439	0.69805625	544.63	0.0001
NF	-0.07500001	0.00316439	0.72000027	561.75	0.0001
B	-0.03360571	0.00316439	0.14455597	112.78	0.0001
RCS	0.09726889	0.00316439	1.21103842	944.86	0.0001
PFA	0.13710155	0.00316439	2.40599477	1877.18	0.0001
PD	-0.25427339	0.00316439	8.27583472	6456.88	0.0001
N	0.08941405	0.00316439	1.02334377	798.42	0.0001
PFAPD	-0.02380466	0.00316439	0.07253274	56.59	0.0001

BOUNDS ON CONDITION NUMBER: 1, 81

STEP 10 VARIABLE L ENTERED R SQUARE = 0.99827057
C(P) = 280983.180525

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	10	49.89616783	4.98961678	6753.54	0.0001
ERROR	117	0.08644131	0.00073881		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
G	0.52500008	0.00240250	35.28001071	47752.18	0.0001
F	-0.07384825	0.00240250	0.69805625	944.83	0.0001
NF	-0.07500001	0.00240250	0.72000027	974.53	0.0001
L	-0.02250004	0.00240250	0.06480021	87.71	0.0001
B	-0.03360571	0.00240250	0.14455597	195.66	0.0001
RCS	0.09726889	0.00240250	1.21103842	1639.16	0.0001
PFA	0.13710155	0.00240250	2.40599477	3256.56	0.0001
PD	-0.25427339	0.00240250	8.27583472	11201.50	0.0001
N	0.08941405	0.00240250	1.02334377	1385.12	0.0001
PFAPD	-0.02380466	0.00240250	0.07253274	98.17	0.0001

BOUNDS ON CONDITION NUMBER: 1, 100

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 11 VARIABLE P ENTERED R SQUARE = 0.99951132
C(P) = 79322.1097443

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	11	49.95818381	4.54165307	21569.07	0.0001
ERROR	116	0.02442533	0.00021056		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
P	0.02201136	0.00128259	0.06201597	294.52	0.0001
G	0.52500008	0.00128259	35.28001071	167550.68	0.0001
F	-0.07384825	0.00128259	0.69805625	3315.19	0.0001
NF	-0.07500001	0.00128259	0.72000027	3419.40	0.0001
L	-0.02250004	0.00128259	0.06480021	307.75	0.0001
B	-0.03360571	0.00128259	0.14455597	686.52	0.0001
RCS	0.09726889	0.00128259	1.21103842	5751.42	0.0001
PFA	0.13710155	0.00128259	2.40599477	11426.47	0.0001
PD	-0.25427339	0.00128259	8.27583472	39303.33	0.0001
N	0.08941405	0.00128259	1.02334377	4860.03	0.0001
PFAPD	-0.02380466	0.00128259	0.07253274	344.47	0.0001

BOUNDS ON CONDITION NUMBER: 1, 121

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 12 VARIABLE PFAN ENTERED R SQUARE = 0.99988539
C(P) = 18525.8724601

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	12	49.97688065	4.16474005	83607.51	0.0001
ERROR	115	0.00572849	0.00004981		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
P	0.02201136	0.00062383	0.06201597	1244.98	0.0001
G	0.52500008	0.00062383	35.28001071	708249.20	0.0001
F	-0.07384825	0.00062383	0.69805625	14013.54	0.0001
NF	-0.07500001	0.00062383	0.72000027	14454.07	0.0001
L	-0.02250004	0.00062383	0.06480021	1300.87	0.0001
B	-0.03360571	0.00062383	0.14455597	2901.97	0.0001
RCS	0.09726889	0.00062383	1.21103842	24311.70	0.0001
PFA	0.13710155	0.00062383	2.40599477	48300.55	0.0001
PD	-0.25427339	0.00062383	8.27583472	166138.08	0.0001
N	0.08941405	0.00062383	1.02334377	20543.71	0.0001
PFAPD	-0.02380466	0.00062383	0.07253274	1456.10	0.0001
PFAN	-0.01208590	0.00062383	0.01869684	375.34	0.0001

BOUNDS ON CONDITION NUMBER: 1, 144

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 13 VARIABLE T ENTERED R SQUARE = 0.99995251
C(P) = 7617.94665910

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	13	49.98023570	3.84463352	184663.40	0.0001
ERROR	114	0.00237344	0.00002082		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
P	0.02201136	0.00040330	0.06201597	2978.72	0.0001
G	0.52500008	0.00040330	35.28001071	999999.99	0.0001
F	-0.07384825	0.00040330	0.69805625	33528.67	0.0001
NF	-0.07500001	0.00040330	0.72000027	34582.67	0.0001
L	-0.02250004	0.00040330	0.06480021	3112.45	0.0001
B	-0.03360571	0.00040330	0.14455597	6943.24	0.0001
RCS	0.09726889	0.00040330	1.21103842	58167.96	0.0001
T	-0.00511970	0.00040330	0.00335505	161.15	0.0001
PFA	0.13710155	0.00040330	2.40599477	115563.47	0.0001
PD	-0.25427339	0.00040330	8.27583472	397500.51	0.0001
N	0.08941405	0.00040330	1.02334377	49152.71	0.0001
PFAPD	-0.02380466	0.00040330	0.07253274	3483.85	0.0001
PFAN	-0.01208590	0.00040330	0.01869684	898.04	0.0001

BOUNDS ON CONDITION NUMBER: 1, 169

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 14 VARIABLE PDN ENTERED R SQUARE = 0.99999962
C(P) = -36.99999556

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	14	49.98259038	3.57018503	999999.99	0.0001
ERROR	113	0.00001876	0.00000017		
TOTAL	127	49.98260914			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.90537758				
P	0.02201136	0.00003601	0.06201597	373572.55	0.0001
G	0.52500008	0.00003601	35.28001071	999999.99	0.0001
F	-0.07384825	0.00003601	0.69805625	999999.99	0.0001
NF	-0.07500001	0.00003601	0.72000027	999999.99	0.0001
L	-0.02250004	0.00003601	0.06480021	390344.24	0.0001
B	-0.03360571	0.00003601	0.14455597	870777.91	0.0001
RCS	0.09726889	0.00003601	1.21103842	999999.99	0.0001
T	-0.00511970	0.00003601	0.00335505	20210.19	0.0001
PFA	0.13710155	0.00003601	2.40599477	999999.99	0.0001
PD	-0.25427339	0.00003601	8.27583472	999999.99	0.0001
N	0.08941405	0.00003601	1.02334377	999999.99	0.0001
PFAPD	-0.02380466	0.00003601	0.07253274	436923.56	0.0001
PFAN	-0.01208590	0.00003601	0.01869684	112626.23	0.0001
PDN	0.00428905	0.00003601	0.00235469	14184.18	0.0001

BOUNDS ON CONDITION NUMBER: 1, 196

NO OTHER VARIABLES MET THE 0.1500 SIGNIFICANCE LEVEL FOR ENTRY INTO THE MODEL.

RADAR RANGE RESIDUALS

SUMMARY OF STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP	VARIABLE ENTERED	VARIABLE REMOVED	NUMBER IN	PARTIAL R**2	MODEL R**2	C(P)
1	G		1	0.7058	0.7058	4.781E+07
2	PD		2	0.1656	0.8714	2.090E+07
3	PFA		3	0.0481	0.9196	1.307E+07
4	RCS		4	0.0242	0.9438	9.137E+06
5	N		5	0.0205	0.9643	5.809E+06
6	NF		6	0.0144	0.9787	3.468E+06
7	F		7	0.0140	0.9926	1.198E+06
8	B		8	0.0029	0.9955	7.276E+05
9	PFAPD		9	0.0015	0.9970	4.917E+05
10	L		10	0.0013	0.9983	2.810E+05
11	P		11	0.0012	0.9995	7.932E+04
12	PFAN		12	0.0004	0.9999	1.853E+04
13	T		13	0.0001	1.0000	7.618E+03
14	PDN		14	0.0000	1.0000	-3.70E+01

STEP	VARIABLE ENTERED	REMOVED	F	PROB>F
1	G		302.3466	0.0001
2	PD		160.9643	0.0001
3	PFA		74.2006	0.0001
4	RCS		53.0150	0.0001
5	N		69.8885	0.0001
6	NF		81.6965	0.0001
7	F		227.4230	0.0001
8	B		76.8728	0.0001
9	PFAPD		56.5907	0.0001
10	L		87.7083	0.0001
11	P		294.5243	0.0001
12	PFAN		375.3406	0.0001
13	T		161.1480	0.0001
14	PDN		9999.9999	0.0001

APPENDIX G:

SAS OUTPUT FOR RADAR C USING DESIGN 3

DEP VARIABLE: RANGE

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	66	58.74048601	0.89000736	999999.990	0.0001
ERROR	61	.00001875965	3.07535E-07		
C TOTAL	127	58.74050477			

ROOT MSE	0.0005545586	R-SQUARE	1.0000
DEP MEAN	4.870589	ADJ R-SQ	1.0000
C.V.	0.01138586		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	4.87058885	.00004901652	99366.270	0.0001
P	1	0.02201141	.00004901652	449.061	0.0001
G	1	0.58500006	.00004901652	11934.753	0.0001
F	1	-0.0749351	.00004901652	-1528.773	0.0001
NF	1	-0.0862499	.00004901652	-1759.610	0.0001
L	1	-0.01875	.00004901652	-382.524	0.0001
B	1	-0.0336057	.00004901652	-685.599	0.0001
RCS	1	0.09726889	.00004901652	1984.410	0.0001
T	1	-0.0051197	.00004901652	-104.448	0.0001
PFA	1	0.13710155	.00004901652	2797.048	0.0001
PD	1	-0.254273	.00004901652	-5187.504	0.0001
N	1	0.08941402	.00004901652	1824.161	0.0001
PG	1	-6.09375E-08	.00004901652	-0.001	0.9990
PF	1	1.71875E-08	.00004901652	0.000	0.9997
PNF	1	-1.25000E-08	.00004901652	-0.000	0.9998
PL	1	1.25000E-08	.00004901652	0.000	0.9998
PB	1	-4.84375E-08	.00004901652	-0.001	0.9992
PRCS	1	7.81250E-09	.00004901652	0.000	0.9999
PT	1	-2.96875E-08	.00004901652	-0.001	0.9995
PPFA	1	-7.81250E-09	.00004901652	-0.000	0.9999
PPD	1	2.18750E-08	.00004901652	0.000	0.9996
PN	1	7.81250E-09	.00004901652	0.000	0.9999
GF	1	-5.15625E-08	.00004901652	-0.001	0.9992
GNF	1	-6.25000E-09	.00004901652	-0.000	0.9999
GL	1	-6.25000E-09	.00004901652	-0.000	0.9999
GB	1	-3.59375E-08	.00004901652	-0.001	0.9994
GRCS	1	-1.09375E-08	.00004901652	-0.000	0.9998
GT	1	4.68750E-09	.00004901652	0.000	0.9999
GPFA	1	1.71875E-08	.00004901652	0.000	0.9997
GPD	1	2.18750E-08	.00004901652	0.000	0.9996
GN	1	7.81250E-09	.00004901652	0.000	0.9999
FNF	1	-3.12500E-09	.00004901652	-0.000	0.9999

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
FL	1	3.12500E-09	.00004901652	0.000	0.9999
FB	1	-2.34375E-08	.00004901652	-0.000	0.9996
FRCS	1	1.56250E-09	.00004901652	0.000	1.0000
FT	1	7.81250E-09	.00004901652	0.000	0.9999
FPFA	1	-1.40625E-08	.00004901652	-0.000	0.9998
FPD	1	-9.37500E-09	.00004901652	-0.000	0.9998
FN	1	1.09375E-08	.00004901652	0.000	0.9998
NFL	1	7.81250E-09	.00004901652	0.000	0.9999
NFB	1	-1.25000E-08	.00004901652	-0.000	0.9998
NFRCS	1	1.25000E-08	.00004901652	0.000	0.9998
NFT	1	3.46945E-18	.00004901652	0.000	1.0000
NFPFA	1	9.37500E-09	.00004901652	0.000	0.9998
NFPD	1	2.03125E-08	.00004901652	0.000	0.9997
NFN	1	1.25000E-08	.00004901652	0.000	0.9998
LB	1	-2.18750E-08	.00004901652	-0.000	0.9996
LRCS	1	9.37500E-09	.00004901652	0.000	0.9998
LT	1	6.25000E-09	.00004901652	0.000	0.9999
LPFA	1	3.12500E-08	.00004901652	0.001	0.9995
LPD	1	4.68750E-09	.00004901652	0.000	0.9999
LN	1	-6.25000E-09	.00004901652	-0.000	0.9999
BRCS	1	-1.56250E-09	.00004901652	-0.000	1.0000
BT	1	1.56250E-09	.00004901652	0.000	1.0000
BPFA	1	1.56250E-09	.00004901652	0.000	1.0000
BPD	1	9.37500E-09	.00004901652	0.000	0.9998
BN	1	-1.40625E-08	.00004901652	-0.000	0.9998
RCST	1	-1.56250E-09	.00004901652	-0.000	1.0000
RCSPFA	1	-1.56250E-09	.00004901652	-0.000	1.0000
RCSPD	1	6.25000E-09	.00004901652	0.000	0.9999
RCSN	1	-7.81250E-09	.00004901652	-0.000	0.9999
TPFA	1	-1.71875E-08	.00004901652	-0.000	0.9997
TPD	1	-1.87500E-08	.00004901652	-0.000	0.9997
TN	1	-1.71875E-08	.00004901652	-0.000	0.9997
PFAPD	1	-0.0238047	.00004901652	-485.646	0.0001
PFAN	1	-0.0120859	.00004901652	-246.568	0.0001
PDN	1	0.004289053	.00004901652	87.502	0.0001

RESIDUAL CALCULATIONS

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
1	4.1518	4.1521	-3.8E-04
2	4.9168	4.9172	-3.8E-04
3	5.2928	5.2932	-3.8E-04
4	5.5845	5.5849	-3.8E-04
5	4.4261	4.4257	3.8E-04
6	3.7959	3.7955	3.8E-04
7	5.7374	5.7370	3.8E-04
8	5.3901	5.3898	3.8E-04
9	4.3932	4.3928	3.8E-04
10	3.7835	3.7831	3.8E-04

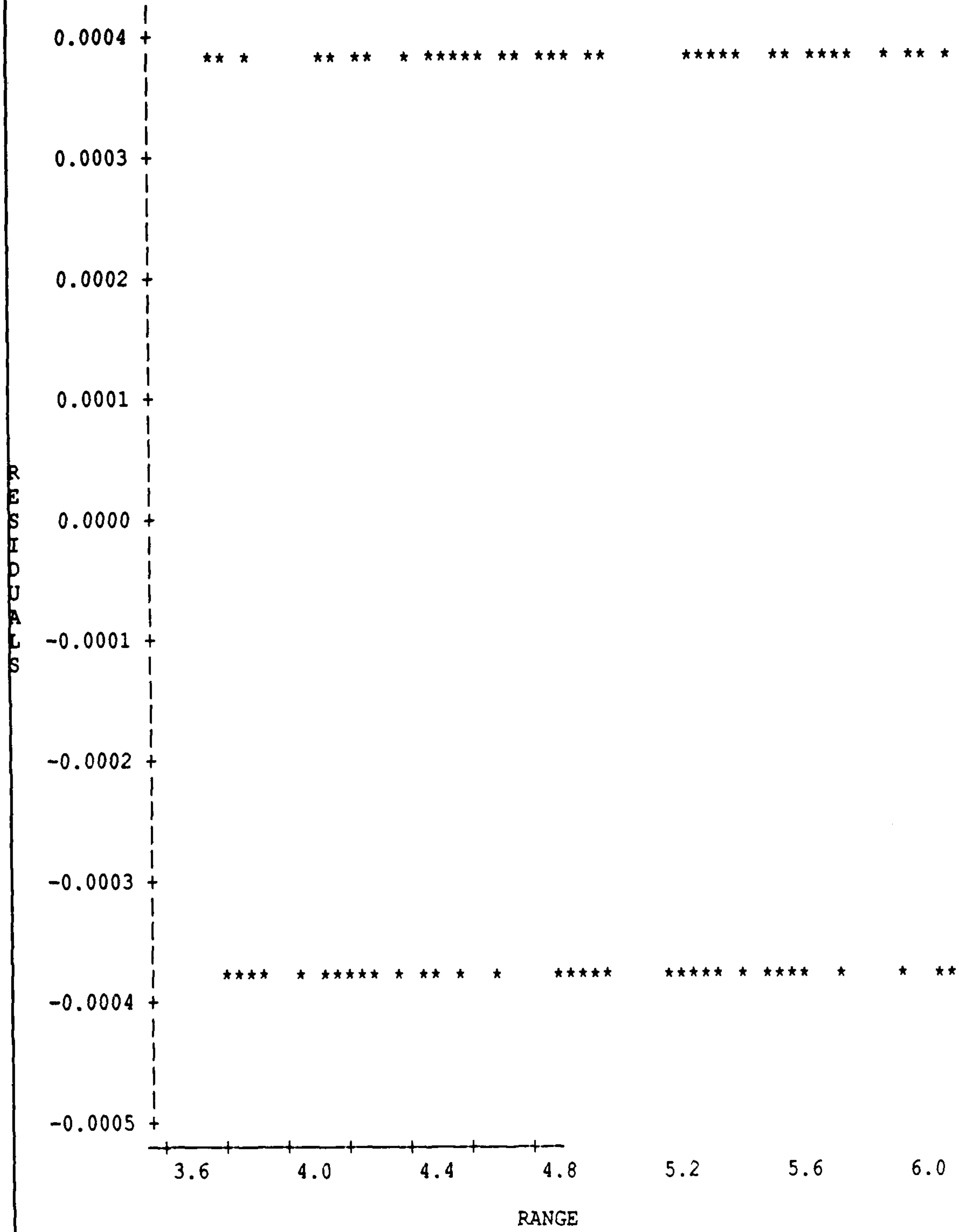
OBS	ACTUAL	PREDICT VALUE	RESIDUAL
11	5.7250	5.7246	3.8E-04
12	5.3573	5.3569	3.8E-04
13	3.8396	3.8400	-3.8E-04
14	4.5842	4.5846	-3.8E-04
15	4.9602	4.9606	-3.8E-04
16	5.2724	5.2728	-3.8E-04
17	4.0751	4.0754	-3.8E-04
18	4.3873	4.3876	-3.8E-04
19	5.2945	5.2949	-3.8E-04
20	6.0391	6.0395	-3.8E-04
21	4.5401	4.5397	3.8E-04
22	4.1724	4.1720	3.8E-04
23	5.5483	5.5479	3.8E-04
24	4.9386	4.9383	3.8E-04
25	4.5073	4.5069	3.8E-04
26	4.1600	4.1596	3.8E-04
27	5.5359	5.5355	3.8E-04
28	4.9058	4.9054	3.8E-04
29	3.7629	3.7633	-3.8E-04
30	4.0547	4.0550	-3.8E-04
31	4.9619	4.9623	-3.8E-04
32	5.7270	5.7273	-3.8E-04
33	4.7954	4.7957	-3.8E-04
34	4.1388	4.1392	-3.8E-04
35	5.4835	5.4839	-3.8E-04
36	5.2594	5.2598	-3.8E-04
37	3.6949	3.6945	3.8E-04
38	4.3926	4.3922	3.8E-04
39	5.2687	5.2683	3.8E-04
40	5.7244	5.7241	3.8E-04
41	3.6620	3.6617	3.8E-04
42	4.3802	4.3799	3.8E-04
43	5.2563	5.2559	3.8E-04
44	5.6916	5.6912	3.8E-04
45	4.4832	4.4836	-3.8E-04
46	3.8062	3.8066	-3.8E-04
47	5.1509	5.1513	-3.8E-04
48	4.9472	4.9476	-3.8E-04
49	4.2658	4.2662	-3.8E-04
50	4.0621	4.0625	-3.8E-04
51	5.9381	5.9385	-3.8E-04
52	5.2611	5.2614	-3.8E-04
53	4.0714	4.0710	3.8E-04
54	4.5067	4.5063	3.8E-04
55	4.8172	4.8168	3.8E-04
56	5.5354	5.5350	3.8E-04
57	4.0385	4.0382	3.8E-04
58	4.4943	4.4939	3.8E-04
59	4.8048	4.8044	3.8E-04
60	5.5025	5.5021	3.8E-04
61	3.9537	3.9540	-3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
62	3.7295	3.7299	-3.8E-04
63	5.6055	5.6059	-3.8E-04
64	4.9489	4.9493	-3.8E-04
65	4.5205	4.5201	3.8E-04
66	4.9558	4.9554	3.8E-04
67	5.2663	5.2659	3.8E-04
68	5.9845	5.9841	3.8E-04
69	4.4152	4.4156	-3.8E-04
70	4.2115	4.2119	-3.8E-04
71	6.0875	6.0879	-3.8E-04
72	5.4104	5.4108	-3.8E-04
73	4.4028	4.4032	-3.8E-04
74	4.1786	4.1790	-3.8E-04
75	6.0546	6.0550	-3.8E-04
76	5.3981	5.3984	-3.8E-04
77	4.1879	4.1875	3.8E-04
78	4.6437	4.6433	3.8E-04
79	4.9542	4.9538	3.8E-04
80	5.6519	5.6515	3.8E-04
81	4.0690	4.0686	3.8E-04
82	4.7668	4.7664	3.8E-04
83	5.6428	5.6424	3.8E-04
84	6.0986	6.0982	3.8E-04
85	4.8697	4.8701	-3.8E-04
86	4.2132	4.2136	-3.8E-04
87	5.5579	5.5583	-3.8E-04
88	5.3338	5.3341	-3.8E-04
89	4.8573	4.8577	-3.8E-04
90	4.1803	4.1807	-3.8E-04
91	5.5250	5.5254	-3.8E-04
92	5.3214	5.3217	-3.8E-04
93	3.7364	3.7360	3.8E-04
94	4.4546	4.4542	3.8E-04
95	5.3307	5.3303	3.8E-04
96	5.7659	5.7656	3.8E-04
97	4.8548	4.8544	3.8E-04
98	4.4871	4.4867	3.8E-04
99	5.8630	5.8626	3.8E-04
100	5.2533	5.2530	3.8E-04
101	4.0900	4.0904	-3.8E-04
102	4.4022	4.4026	-3.8E-04
103	5.3094	5.3098	-3.8E-04
104	6.0540	6.0544	-3.8E-04
105	4.0776	4.0780	-3.8E-04
106	4.3694	4.3697	-3.8E-04
107	5.2766	5.2770	-3.8E-04
108	6.0417	6.0420	-3.8E-04
109	4.5222	4.5218	3.8E-04
110	4.1750	4.1746	3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
111	5.5509	5.5505	3.8E-04
112	4.9207	4.9203	3.8E-04
113	4.6658	4.6654	3.8E-04
114	4.0356	4.0352	3.8E-04
115	5.9771	5.9767	3.8E-04
116	5.6298	5.6295	3.8E-04
117	4.0917	4.0921	-3.8E-04
118	4.8568	4.8572	-3.8E-04
119	5.2328	5.2331	-3.8E-04
120	5.5245	5.5249	-3.8E-04
121	4.0793	4.0797	-3.8E-04
122	4.8239	4.8243	-3.8E-04
123	5.1999	5.2003	-3.8E-04
124	5.5121	5.5125	-3.8E-04
125	4.3331	4.3328	3.8E-04
126	3.7235	3.7231	3.8E-04
127	5.6649	5.6646	3.8E-04
128	5.2972	5.2968	3.8E-04

SUM OF RESIDUALS -2.94764E-14
SUM OF SQUARED RESIDUALS .00001875965

RADAR RANGE RESIDUALS
PLOT OF RESIDUAL*RANGE   SYMBOL USED IS *



NOTE: 59 OBS HIDDEN   RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

NOTE: SLENTRY AND SLSTAY HAVE BEEN SET TO .15 FOR THE STEPWISE TECHNIQUE.

STEP 1 VARIABLE G ENTERED R SQUARE = 0.74573430
C(P) = 48565672.8743

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	1	43.80480913	43.80480913	369.54	0.0001
ERROR	126	14.93569564	0.11853727		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
G	0.58500006	0.03043144	43.80480913	369.54	0.0001

BOUNDS ON CONDITION NUMBER: 1, 1

STEP 2 VARIABLE PD ENTERED R SQUARE = 0.88662236
C(P) = 21655474.8273

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	52.08064487	26.04032243	488.76	0.0001
ERROR	125	6.65985990	0.05327888		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
G	0.58500006	0.02040199	43.80480913	822.18	0.0001
PD	-0.25427341	0.02040199	8.27583574	155.33	0.0001

BOUNDS ON CONDITION NUMBER: 1, 4

STEP 3 VARIABLE PFA ENTERED R SQUARE = 0.92758208
C(P) = 13832001.2067

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	54.48663958	18.16221319	529.43	0.0001
ERROR	124	4.25386518	0.03430536		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
G	0.58500006	0.01637103	43.80480913	1276.91	0.0001
PFA	0.13710155	0.01637103	2.40599472	70.13	0.0001
PD	-0.25427341	0.01637103	8.27583574	241.24	0.0001

BOUNDS ON CONDITION NUMBER: 1, 9

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 4 VARIABLE RCS ENTERED R SQUARE = 0.94819883
C(P) = 9894118.96732

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	55.69767789	13.92441947	562.87	0.0001
ERROR	123	3.04282687	0.02473843		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
G	0.58500006	0.01390212	43.80480913	1770.72	0.0001
RCS	0.09726889	0.01390212	1.21103831	48.95	0.0001
PFA	0.13710155	0.01390212	2.40599472	97.26	0.0001
PD	-0.25427341	0.01390212	8.27583574	334.53	0.0001

BOUNDS ON CONDITION NUMBER: 1, 16

STEP 5 VARIABLE N ENTERED R SQUARE = 0.96562025
C(P) = 6566558.02800

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	h5(	56.72102087	11.34420417	685.32	0.0001
ERROR	122	2.01948390	0.01655315		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
G	0.58500006	0.01137196	43.80480913	2646.31	0.0001
RCS	0.09726889	0.01137196	1.21103831	73.16	0.0001
PFA	0.13710155	0.01137196	2.40599472	145.35	0.0001
PD	-0.25427341	0.01137196	8.27583574	499.96	0.0001
N	0.08941402	0.01137196	1.02334298	61.82	0.0001

BOUNDS ON CONDITION NUMBER: 1, 25

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 6 VARIABLE NF ENTERED R SQUARE = 0.98183051
C(P) = 3470334.09844

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	6	57.67321956	9.61220326	1089.75	0.0001
ERROR	121	1.06728521	0.00882054		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
G	0.58500006	0.00830123	43.80480913	4966.23	0.0001
NF	-0.08624994	0.00830123	0.95219869	107.95	0.0001
RCS	0.09726889	0.00830123	1.21103831	137.30	0.0001
PFA	0.13710155	0.00830123	2.40599472	272.77	0.0001
PD	-0.25427341	0.00830123	8.27583574	938.25	0.0001
N	0.08941402	0.00830123	1.02334298	116.02	0.0001

BOUNDS ON CONDITION NUMBER: 1, 36

STEP 7 VARIABLE F ENTERED R SQUARE = 0.99406661
C(P) = 1133190.05366

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	7	58.39197441	8.34171063	2872.07	0.0001
ERROR	120	0.34853036	0.00290442		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
G	0.58500006	0.00476348	43.80480913	15082.12	0.0001
F	-0.07493512	0.00476348	0.71875485	247.47	0.0001
NF	-0.08624994	0.00476348	0.95219869	327.84	0.0001
RCS	0.09726889	0.00476348	1.21103831	416.96	0.0001
PFA	0.13710155	0.00476348	2.40599472	828.39	0.0001
PD	-0.25427341	0.00476348	8.27583574	2849.39	0.0001
N	0.08941402	0.00476348	1.02334298	352.34	0.0001

BOUNDS ON CONDITION NUMBER: 1, 49

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 8 VARIABLE B ENTERED R SQUARE = 0.99652753
C(P) = 663145.398737

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	8	58.53653033	7.31706629	4268.82	0.0001
ERROR	119	0.20397443	0.00171407		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
G	0.58500006	0.00365940	43.80480913	25556.01	0.0001
F	-0.07493512	0.00365940	0.71875485	419.33	0.0001
NF	-0.08624994	0.00365940	0.95219869	555.52	0.0001
B	-0.03360570	0.00365940	0.14455593	84.33	0.0001
RCS	0.09726889	0.00365940	1.21103831	706.53	0.0001
PFA	0.13710155	0.00365940	2.40599472	1403.67	0.0001
PD	-0.25427341	0.00365940	8.27583574	4828.18	0.0001
N	0.08941402	0.00365940	1.02334298	597.02	0.0001

BOUNDS ON CONDITION NUMBER: 1, 64

STEP 9 VARIABLE PFAPD ENTERED R SQUARE = 0.99776233
C(P) = 427295.655404

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	9	58.60906307	6.51211812	5846.17	0.0001
ERROR	118	0.13144170	0.00111391		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
G	0.58500006	0.00294999	43.80480913	39325.17	0.0001
F	-0.07493512	0.00294999	0.71875485	645.25	0.0001
NF	-0.08624994	0.00294999	0.95219869	854.82	0.0001
B	-0.03360570	0.00294999	0.14455593	129.77	0.0001
RCS	0.09726889	0.00294999	1.21103831	1087.19	0.0001
PFA	0.13710155	0.00294999	2.40599472	2159.95	0.0001
PD	-0.25427341	0.00294999	8.27583574	7429.52	0.0001
N	0.08941402	0.00294999	1.02334298	918.69	0.0001
PFAPD	-0.02380466	0.00294999	0.07253273	65.12	0.0001

BOUNDS ON CONDITION NUMBER: 1, 81

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 10 VARIABLE P ENTERED R SQUARE = 0.99881810
C(P) = 225641.761077

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	10	58.67107937	5.86710794	9887.62	0.0001
ERROR	117	0.06942540	0.00059338		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
P	0.02201141	0.00215309	0.06201630	104.51	0.0001
G	0.58500006	0.00215309	43.80480913	73822.59	0.0001
F	-0.07493512	0.00215309	0.71875485	1211.29	0.0001
NF	-0.08624994	0.00215309	0.95219869	1604.70	0.0001
B	-0.03360570	0.00215309	0.14455593	243.61	0.0001
RCS	0.09726889	0.00215309	1.21103831	2040.92	0.0001
PFA	0.13710155	0.00215309	2.40599472	4054.73	0.0001
PD	-0.25427341	0.00215309	8.27583574	13946.95	0.0001
N	0.08941402	0.00215309	1.02334298	1724.60	0.0001
PFAPD	-0.02380466	0.00215309	0.07253273	122.24	0.0001

BOUNDS ON CONDITION NUMBER: 1, 100

STEP 11 VARIABLE L ENTERED R SQUARE = 0.99958418
C(P) = 79318.9852437

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	11	58.71607940	5.33782540	25350.19	0.0001
ERROR	116	0.02442537	0.00021056		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
P	0.02201141	0.00128259	0.06201630	294.53	0.0001
G	0.58500006	0.00128259	43.80480913	208036.07	0.0001
F	-0.07493512	0.00128259	0.71875485	3413.48	0.0001
NF	-0.08624994	0.00128259	0.95219869	4522.14	0.0001
L	-0.01875001	0.00128259	0.04500003	213.71	0.0001
B	-0.03360570	0.00128259	0.14455593	686.52	0.0001
RCS	0.09726889	0.00128259	1.21103831	5751.42	0.0001
PFA	0.13710155	0.00128259	2.40599472	11426.46	0.0001
PD	-0.25427341	0.00128259	8.27583574	39303.27	0.0001
N	0.08941402	0.00128259	1.02334298	4860.02	0.0001
PFAPD	-0.02380466	0.00128259	0.07253273	344.47	0.0001

BOUNDS ON CONDITION NUMBER: 1, 121

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 12 VARIABLE PFAN ENTERED R SQUARE = 0.99990248
C(P) = 18525.1208677

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	12	58.73477627	4.89456469	98258.75	0.0001
ERROR	115	0.00572850	0.00004981		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
P	0.02201141	0.00062383	0.06201630	1244.98	0.0001
G	0.58500006	0.00062383	43.80480913	879384.82	0.0001
F	-0.07493512	0.00062383	0.71875485	14429.06	0.0001
NF	-0.08624994	0.00062383	0.95219869	19115.46	0.0001
L	-0.01875001	0.00062383	0.04500003	903.38	0.0001
B	-0.03360570	0.00062383	0.14455593	2901.97	0.0001
RCS	0.09726889	0.00062383	1.21103831	24311.68	0.0001
PFA	0.13710155	0.00062383	2.40599472	48300.52	0.0001
PD	-0.25427341	0.00062383	8.27583574	166138.02	0.0001
N	0.08941402	0.00062383	1.02334298	20543.69	0.0001
PFAPD	-0.02380466	0.00062383	0.07253273	1456.10	0.0001
PFAN	-0.01208591	0.00062383	0.01869687	375.34	0.0001

BOUNDS ON CONDITION NUMBER: 1, 144

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 13 VARIABLE T ENTERED R SQUARE = 0.99995959
C(P) = 7617.63395936

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	13	58.73813132	4.51831779	217021.38	0.0001
ERROR	114	0.00237344	0.00002082		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
P	0.02201141	0.00040330	0.06201630	2978.73	0.0001
G	0.58500006	0.00040330	43.80480913	999999.99	0.0001
F	-0.07493512	0.00040330	0.71875485	34522.84	0.0001
NF	-0.08624994	0.00040330	0.95219869	45735.49	0.0001
L	-0.01875001	0.00040330	0.04500003	2161.42	0.0001
B	-0.03360570	0.00040330	0.14455593	6943.23	0.0001
RCS	0.09726889	0.00040330	1.21103831	58167.93	0.0001
T	-0.00511970	0.00040330	0.00335505	161.15	0.0001
PFA	0.13710155	0.00040330	2.40599472	115563.43	0.0001
PD	-0.25427341	0.00040330	8.27583574	397500.43	0.0001
N	0.08941402	0.00040330	1.02334298	49152.65	0.0001
PFAPD	-0.02380466	0.00040330	0.07253273	3483.85	0.0001
PFAN	-0.01208591	0.00040330	0.01869687	898.04	0.0001

BOUNDS ON CONDITION NUMBER: 1, 169

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 14   VARIABLE PDN ENTERED   R SQUARE = 0.99999968
C(P) = -36.99999240

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	14	58.74048601	4.19574900	999999.99	0.0001
ERROR	113	0.00001876	0.00000017		
TOTAL	127	58.74050477			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.87058885				
P	0.02201141	0.00003601	0.06201630	373559.23	0.0001
G	0.58500006	0.00003601	43.80480913	999999.99	0.0001
F	-0.07493512	0.00003601	0.71875485	999999.99	0.0001
NF	-0.08624994	0.00003601	0.95219869	999999.99	0.0001
L	-0.01875001	0.00003601	0.04500003	271060.62	0.0001
B	-0.03360570	0.00003601	0.14455593	870742.06	0.0001
RCS	0.09726889	0.00003601	1.21103831	999999.99	0.0001
T	-0.00511970	0.00003601	0.00335505	20209.37	0.0001
PFA	0.13710155	0.00003601	2.40599472	999999.99	0.0001
PD	-0.25427341	0.00003601	8.27583574	999999.99	0.0001
N	0.08941402	0.00003601	1.02334298	999999.99	0.0001
PFAPD	-0.02380466	0.00003601	0.07253273	436905.63	0.0001
PFAN	-0.01208591	0.00003601	0.01869687	112621.83	0.0001
PDN	0.00428905	0.00003601	0.00235469	14183.60	0.0001

BOUNDS ON CONDITION NUMBER: 1, 196

NO OTHER VARIABLES MET THE 0.1500 SIGNIFICANCE LEVEL FOR ENTRY INTO THE MODEL.

RADAR RANGE RESIDUALS

SUMMARY OF STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP	VARIABLE ENTERED	VARIABLE REMOVED	NUMBER IN	PARTIAL R**2	MODEL R**2	C(P)
1	G		1	0.7457	0.7457	4.857E+07
2	PD		2	0.1409	0.8866	2.166E+07
3	PFA		3	0.0410	0.9276	1.383E+07
4	RCS		4	0.0206	0.9482	9.894E+06
5	N		5	0.0174	0.9656	6.567E+06
6	NF		6	0.0162	0.9818	3.470E+06
7	F		7	0.0122	0.9941	1.133E+06
8	B		8	0.0025	0.9965	6.631E+05
9	PFAPD		9	0.0012	0.9978	4.273E+05
10	P		10	0.0011	0.9988	2.256E+05
11	L		11	0.0008	0.9996	7.932E+04
12	PFAN		12	0.0003	0.9999	1.853E+04
13	T		13	0.0001	1.0000	7.618E+03
14	PDN		14	0.0000	1.0000	-3.70E+01

	VARIABLE			
STEP	ENTERED	REMOVED	F	PROB>F
1	G		369.5446	0.0001
2	PD		155.3305	0.0001
3	PFA		70.1346	0.0001
4	RCS		48.9537	0.0001
5	N		61.8217	0.0001
6	NF		107.9524	0.0001
7	F		247.4694	0.0001
8	B		84.3349	0.0001
9	PFAPD		65.1153	0.0001
10	P		104.5137	0.0001
11	L		213.7124	0.0001
12	PFAN		375.3411	0.0001
13	T		161.1480	0.0001
14	PDN		9999.9999	0.0001

APPENDIX H:

SAS OUTPUT FOR RADAR X USING DESIGN 3

DEP VARIABLE: RANGE

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	78	106.63832861	1.36715806	999999.990	0.0001
ERROR	177	.00003751487	2.11948E-07		
C TOTAL	255	106.63836612			

ROOT MSE	0.0004603785	R-SQUARE	1.0000
DEP MEAN	5.501767	ADJ R-SQ	1.0000
C.V.	0.008367831		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	5.50176666	.00002877366	99999.999	0.0001
P	1	0.22661417	.00002877366	7875.751	0.0001
GT	1	0.36974998	.00002877366	12850.294	0.0001
GR	1	0.33975007	.00002877366	11807.677	0.0001
F	1	-0.0759095	.00002877366	-2638.158	0.0001
NF	1	-0.06	.00002877366	-2085.241	0.0001
L	1	-0.03	.00002877366	-1042.619	0.0001
B	1	-0.0336056	.00002877366	-1167.930	0.0001
RCS	1	0.09726889	.00002877366	3380.484	0.0001
T	1	-0.00511972	.00002877366	-177.931	0.0001
PFA	1	0.13710156	.00002877366	4764.829	0.0001
PD	1	-0.254273	.00002877366	-8837.021	0.0001
N	1	0.08941403	.00002877366	3107.496	0.0001
PGT	1	1.17187E-08	.00002877366	0.000	0.9997
PGR	1	1.48437E-08	.00002877366	0.001	0.9996
PF	1	-3.20312E-08	.00002877366	-0.001	0.9991
PNF	1	1.56250E-08	.00002877366	0.001	0.9996
PL	1	1.56250E-08	.00002877366	0.001	0.9996
PB	1	-1.64063E-08	.00002877366	-0.001	0.9995
PRCS	1	1.64062E-08	.00002877366	0.001	0.9995
PT	1	-4.60938E-08	.00002877366	-0.002	0.9987
PPFA	1	-6.25000E-09	.00002877366	-0.000	0.9998
PPD	1	2.81250E-08	.00002877366	0.001	0.9992
PN	1	-3.90625E-09	.00002877366	-0.000	0.9999
GTGR	1	5.54688E-08	.00002877366	0.002	0.9985
GTF	1	-4.45313E-08	.00002877366	-0.002	0.9988
GTNF	1	7.81250E-09	.00002877366	0.000	0.9998
GTL	1	4.68750E-09	.00002877366	0.000	0.9999
GTB	1	4.29687E-08	.00002877366	0.001	0.9988
GTRCS	1	1.17187E-08	.00002877366	0.000	0.9997
GTT	1	1.01562E-08	.00002877366	0.000	0.9997
GTPFA	1	-9.37500E-09	.00002877366	-0.000	0.9997

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
GTPD	1	-6.25000E-09	.00002877366	-0.000	0.9998
GTN	1	3.90625E-09	.00002877366	0.000	0.9999
GRF	1	-4.14062E-08	.00002877366	-0.001	0.9989
GRNF	1	4.68750E-09	.00002877366	0.000	0.9999
GRL	1	1.71875E-08	.00002877366	0.001	0.9995
GRB	1	3.35937E-08	.00002877366	0.001	0.9991
GRRCS	1	1.64062E-08	.00002877366	0.001	0.9995
GRT	1	-7.81250E-10	.00002877366	-0.000	1.0000
GRPFA	1	-1.09375E-08	.00002877366	-0.000	0.9997
GRPD	1	-1.56250E-08	.00002877366	-0.001	0.9996
GRN	1	7.81250E-10	.00002877366	0.000	1.0000
FNF	1	-2.03125E-08	.00002877366	-0.001	0.9994
FL	1	1.09375E-08	.00002877366	0.000	0.9997
FB	1	7.03125E-09	.00002877366	0.000	0.9998
FRCS	1	-8.59375E-09	.00002877366	-0.000	0.9998
FT	1	-1.48438E-08	.00002877366	-0.001	0.9996
FPFA	1	2.18750E-08	.00002877366	0.001	0.9994
FPD	1	-2.03125E-08	.00002877366	-0.001	0.9994
FN	1	-8.59375E-09	.00002877366	-0.000	0.9998
NFL	1	-3.90625E-09	.00002877366	-0.000	0.9999
NFB	1	1.71875E-08	.00002877366	0.001	0.9995
NFRCS	1	9.37500E-09	.00002877366	0.000	0.9997
NFT	1	6.25000E-09	.00002877366	0.000	0.9998
NFPFA	1	-5.54688E-08	.00002877366	-0.002	0.9985
NFPD	1	-1.01562E-08	.00002877366	-0.000	0.9997
NFN	1	3.12500E-09	.00002877366	0.000	0.9999
LB	1	9.37500E-09	.00002877366	0.000	0.9997
LRCS	1	8.67362E-18	.00002877366	0.000	1.0000
LT	1	-1.09375E-08	.00002877366	-0.000	0.9997
LPFA	1	-1.01563E-08	.00002877366	-0.000	0.9997
LPD	1	-3.67187E-08	.00002877366	-0.001	0.9990
LN	1	-1.40625E-08	.00002877366	-0.000	0.9996
BRCS	1	-7.81250E-10	.00002877366	-0.000	1.0000
BT	1	-5.46875E-09	.00002877366	-0.000	0.9998
BPFA	1	6.25000E-09	.00002877366	0.000	0.9998
BPD	1	-6.25000E-09	.00002877366	-0.000	0.9998
BN	1	-2.34375E-09	.00002877366	-0.000	0.9999
RCST	1	1.01562E-08	.00002877366	0.000	0.9997
RCSPFA	1	7.81250E-09	.00002877366	0.000	0.9998
RCSPD	1	-3.59375E-08	.00002877366	-0.001	0.9990
RCSN	1	2.26562E-08	.00002877366	0.001	0.9994
TPFA	1	1.87500E-08	.00002877366	0.001	0.9995
TPD	1	-2.60209E-18	.00002877366	-0.000	1.0000
TN	1	2.34375E-09	.00002877366	0.000	0.9999
PFAPD	1	-0.0238047	.00002877366	-827.308	0.0001
PFAN	1	-0.0120859	.00002877366	-420.034	0.0001
PDN	1	0.004289052	.00002877366	149.062	0.0001

RESIDUAL CALCULATIONS

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
1	4.6038	4.6034	3.8E-04
2	5.4688	5.4684	3.8E-04
3	4.9395	4.9392	3.8E-04
4	6.0465	6.0461	3.8E-04
5	5.3483	5.3487	-3.8E-04
6	5.5333	5.5337	-3.8E-04
7	6.5696	6.5700	-3.8E-04
8	6.3223	6.3227	-3.8E-04
9	4.5067	4.5071	-3.8E-04
10	4.7123	4.7126	-3.8E-04
11	5.7485	5.7489	-3.8E-04
12	5.4807	5.4811	-3.8E-04
13	5.1417	5.1413	3.8E-04
14	5.9862	5.9858	3.8E-04
15	5.4570	5.4566	3.8E-04
16	6.5844	6.5840	3.8E-04
17	4.0698	4.0694	3.8E-04
18	5.1972	5.1968	3.8E-04
19	5.2335	5.2332	3.8E-04
20	6.0780	6.0776	3.8E-04
21	5.7204	5.7207	-3.8E-04
22	5.4525	5.4529	-3.8E-04
23	5.9576	5.9579	-3.8E-04
24	6.1631	6.1635	-3.8E-04
25	4.8788	4.8792	-3.8E-04
26	4.6315	4.6318	-3.8E-04
27	5.1365	5.1369	-3.8E-04
28	5.3215	5.3219	-3.8E-04
29	4.6077	4.6073	3.8E-04
30	5.7146	5.7143	3.8E-04
31	5.7510	5.7506	3.8E-04
32	6.6160	6.6156	3.8E-04
33	4.9453	4.9449	3.8E-04
34	5.0073	5.0069	3.8E-04
35	5.5435	5.5431	3.8E-04
36	5.3225	5.3221	3.8E-04
37	5.0304	5.0307	-3.8E-04
38	5.7313	5.7317	-3.8E-04
39	5.7988	5.7992	-3.8E-04
40	6.9731	6.9735	-3.8E-04
41	4.1888	4.1892	-3.8E-04
42	4.9102	4.9106	-3.8E-04
43	4.9777	4.9781	-3.8E-04
44	6.1315	6.1319	-3.8E-04
45	5.4832	5.4828	3.8E-04
46	5.5247	5.5243	3.8E-04
47	6.0609	6.0605	3.8E-04
48	5.8605	5.8601	3.8E-04
49	4.6737	4.6734	3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
50	4.4733	4.4729	3.8E-04
51	5.5750	5.5747	3.8E-04
52	5.6165	5.6161	3.8E-04
53	4.9495	4.9499	-3.8E-04
54	6.1033	6.1037	-3.8E-04
55	5.6396	5.6400	-3.8E-04
56	6.3610	6.3614	-3.8E-04
57	4.1080	4.1084	-3.8E-04
58	5.2823	5.2826	-3.8E-04
59	4.8185	4.8189	-3.8E-04
60	5.5195	5.5198	-3.8E-04
61	5.2117	5.2113	3.8E-04
62	4.9907	4.9903	3.8E-04
63	6.0925	6.0921	3.8E-04
64	6.1545	6.1541	3.8E-04
65	4.3828	4.3832	-3.8E-04
66	5.5366	5.5370	-3.8E-04
67	5.0729	5.0733	-3.8E-04
68	5.7943	5.7947	-3.8E-04
69	5.4660	5.4656	3.8E-04
70	5.2656	5.2652	3.8E-04
71	6.3673	6.3669	3.8E-04
72	6.4088	6.4084	3.8E-04
73	4.6449	4.6446	3.8E-04
74	4.4240	4.4236	3.8E-04
75	5.5258	5.5254	3.8E-04
76	5.5877	5.5874	3.8E-04
77	4.9003	4.9007	-3.8E-04
78	6.0746	6.0749	-3.8E-04
79	5.6108	5.6112	-3.8E-04
80	6.3117	6.3121	-3.8E-04
81	4.2236	4.2240	-3.8E-04
82	4.9246	4.9250	-3.8E-04
83	4.9921	4.9925	-3.8E-04
84	6.1664	6.1668	-3.8E-04
85	5.4976	5.4972	3.8E-04
86	5.5596	5.5592	3.8E-04
87	6.0958	6.0954	3.8E-04
88	5.8748	5.8744	3.8E-04
89	4.6765	4.6761	3.8E-04
90	4.7180	4.7176	3.8E-04
91	5.2542	5.2538	3.8E-04
92	5.0537	5.0534	3.8E-04
93	4.7411	4.7415	-3.8E-04
94	5.4625	5.4629	-3.8E-04
95	5.5300	5.5304	-3.8E-04
96	6.6838	6.6842	-3.8E-04
97	5.0336	5.0340	-3.8E-04
98	4.7658	4.7662	-3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
99	5.2708	5.2712	-3.8E-04
100	5.4764	5.4768	-3.8E-04
101	4.7421	4.7417	3.8E-04
102	5.8695	5.8691	3.8E-04
103	5.9058	5.9054	3.8E-04
104	6.7503	6.7499	3.8E-04
105	3.9210	3.9206	3.8E-04
106	5.0279	5.0276	3.8E-04
107	5.0643	5.0639	3.8E-04
108	5.9292	5.9289	3.8E-04
109	5.5511	5.5515	-3.8E-04
110	5.3037	5.3041	-3.8E-04
111	5.8088	5.8091	-3.8E-04
112	5.9938	5.9942	-3.8E-04
113	4.4216	4.4220	-3.8E-04
114	4.6066	4.6070	-3.8E-04
115	5.6429	5.6433	-3.8E-04
116	5.3956	5.3959	-3.8E-04
117	5.0361	5.0357	3.8E-04
118	5.9011	5.9007	3.8E-04
119	5.3718	5.3714	3.8E-04
120	6.4788	6.4784	3.8E-04
121	4.2150	4.2146	3.8E-04
122	5.0595	5.0591	3.8E-04
123	4.5303	4.5299	3.8E-04
124	5.6577	5.6573	3.8E-04
125	4.9390	4.9394	-3.8E-04
126	5.1446	5.1449	-3.8E-04
127	6.1808	6.1812	-3.8E-04
128	5.9130	5.9134	-3.8E-04
129	4.6343	4.6347	-3.8E-04
130	5.8086	5.8090	-3.8E-04
131	5.3449	5.3453	-3.8E-04
132	6.0458	6.0462	-3.8E-04
133	5.7380	5.7376	3.8E-04
134	5.5171	5.5167	3.8E-04
135	6.6188	6.6185	3.8E-04
136	6.6808	6.6804	3.8E-04
137	4.8965	4.8961	3.8E-04
138	4.6960	4.6956	3.8E-04
139	5.7978	5.7974	3.8E-04
140	5.8392	5.8389	3.8E-04
141	5.1723	5.1726	-3.8E-04
142	6.3261	6.3264	-3.8E-04
143	5.8623	5.8627	-3.8E-04
144	6.5837	6.5841	-3.8E-04
145	4.4752	4.4755	-3.8E-04
146	5.1966	5.1969	-3.8E-04

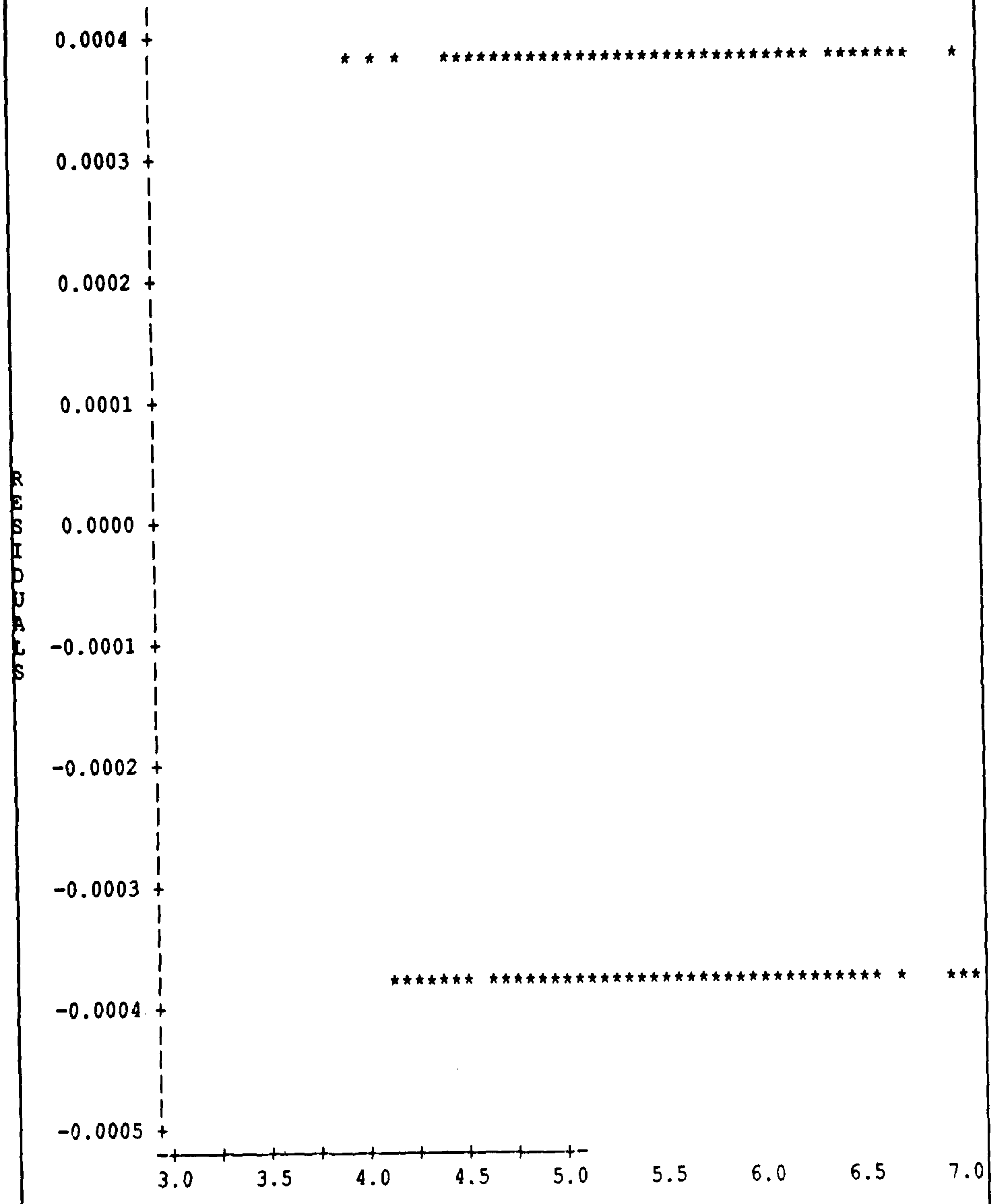
OBS	ACTUAL	PREDICT VALUE	RESIDUAL
147	5.2641	5.2645	-3.8E-04
148	6.4179	6.4183	-3.8E-04
149	5.7696	5.7692	3.8E-04
150	5.8111	5.8107	3.8E-04
151	6.3473	6.3469	3.8E-04
152	6.1468	6.1464	3.8E-04
153	4.9280	4.9276	3.8E-04
154	4.9900	4.9896	3.8E-04
155	5.5262	5.5258	3.8E-04
156	5.3052	5.3049	3.8E-04
157	5.0131	5.0135	-3.8E-04
158	5.7140	5.7144	-3.8E-04
159	5.7815	5.7819	-3.8E-04
160	6.9558	6.9562	-3.8E-04
161	5.2852	5.2855	-3.8E-04
162	5.0378	5.0382	-3.8E-04
163	5.5428	5.5432	-3.8E-04
164	5.7279	5.7283	-3.8E-04
165	5.0141	5.0137	3.8E-04
166	6.1210	6.1206	3.8E-04
167	6.1573	6.1570	3.8E-04
168	7.0223	7.0219	3.8E-04
169	4.1725	4.1721	3.8E-04
170	5.2999	5.2995	3.8E-04
171	5.3363	5.3359	3.8E-04
172	6.1807	6.1804	3.8E-04
173	5.8231	5.8235	-3.8E-04
174	5.5552	5.5556	-3.8E-04
175	6.0603	6.0607	-3.8E-04
176	6.2658	6.2662	-3.8E-04
177	4.6731	4.6735	-3.8E-04
178	4.8786	4.8790	-3.8E-04
179	5.9149	5.9153	-3.8E-04
180	5.6471	5.6475	-3.8E-04
181	5.3081	5.3077	3.8E-04
182	6.1526	6.1522	3.8E-04
183	5.6233	5.6230	3.8E-04
184	6.7507	6.7504	3.8E-04
185	4.4665	4.4661	3.8E-04
186	5.3315	5.3311	3.8E-04
187	4.8023	4.8019	3.8E-04
188	5.9092	5.9088	3.8E-04
189	5.2110	5.2114	-3.8E-04
190	5.3961	5.3964	-3.8E-04
191	6.4323	6.4327	-3.8E-04
192	6.1850	6.1854	-3.8E-04
193	4.7414	4.7410	3.8E-04
194	5.5859	5.5855	3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
195	5.0566	5.0562	3.8E-04
196	6.1840	6.1837	3.8E-04
197	5.4654	5.4658	-3.8E-04
198	5.6709	5.6713	-3.8E-04
199	6.7072	6.7076	-3.8E-04
200	6.4394	6.4397	-3.8E-04
201	4.6443	4.6447	-3.8E-04
202	4.8294	4.8297	-3.8E-04
203	5.8656	5.8660	-3.8E-04
204	5.6183	5.6187	-3.8E-04
205	5.2588	5.2584	3.8E-04
206	6.1238	6.1234	3.8E-04
207	5.5945	5.5942	3.8E-04
208	6.7015	6.7011	3.8E-04
209	4.2074	4.2070	3.8E-04
210	5.3143	5.3139	3.8E-04
211	5.3506	5.3502	3.8E-04
212	6.2156	6.2152	3.8E-04
213	5.8374	5.8378	-3.8E-04
214	5.5901	5.5905	-3.8E-04
215	6.0951	6.0955	-3.8E-04
216	6.2802	6.2806	-3.8E-04
217	5.0164	5.0167	-3.8E-04
218	4.7485	4.7489	-3.8E-04
219	5.2536	5.2539	-3.8E-04
220	5.4591	5.4595	-3.8E-04
221	4.7248	4.7244	3.8E-04
222	5.8522	5.8518	3.8E-04
223	5.8885	5.8882	3.8E-04
224	6.7330	6.7327	3.8E-04
225	5.0829	5.0825	3.8E-04
226	5.1244	5.1240	3.8E-04
227	5.6606	5.6602	3.8E-04
228	5.4601	5.4597	3.8E-04
229	5.1474	5.1478	-3.8E-04
230	5.8688	5.8692	-3.8E-04
231	5.9364	5.9368	-3.8E-04
232	7.0902	7.0906	-3.8E-04
233	4.3264	4.3267	-3.8E-04
234	5.0273	5.0277	-3.8E-04
235	5.0948	5.0952	-3.8E-04
236	6.2691	6.2695	-3.8E-04
237	5.6003	5.5999	3.8E-04
238	5.6623	5.6619	3.8E-04
239	6.1985	6.1981	3.8E-04
240	5.9775	5.9772	3.8E-04
241	4.8113	4.8109	3.8E-04
242	4.5904	4.5900	3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
243	5.6921	5.6917	3.8E-04
244	5.7541	5.7537	3.8E-04
245	5.0666	5.0670	-3.8E-04
246	6.2409	6.2413	-3.8E-04
247	5.7772	5.7776	-3.8E-04
248	6.4781	6.4785	-3.8E-04
249	4.2455	4.2459	-3.8E-04
250	5.3994	5.3997	-3.8E-04
251	4.9356	4.9360	-3.8E-04
252	5.6570	5.6574	-3.8E-04
253	5.3287	5.3284	3.8E-04
254	5.1283	5.1279	3.8E-04
255	6.2300	6.2297	3.8E-04
256	6.2715	6.2712	3.8E-04

SUM OF RESIDUALS -4.82947E-14
SUM OF SQUARED RESIDUALS .00003751487

RADAR RANGE RESIDUALS
PLOT OF RESIDUAL*RANGE   SYMBOL USED IS *



NOTE: 172 OBS HIDDEN   RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

NOTE: SLENTRY AND SLSTAY HAVE BEEN SET TO .15 FOR THE STEPWISE TECHNIQUE.

STEP 1 VARIABLE GT ENTERED R SQUARE = 0.32820319
C(P) = 338003319.552

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	1	34.99905142	34.99905142	124.09	0.0001
ERROR	254	71.63931471	0.28204455		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
GT	0.36974998	0.03319242	34.99905142	124.09	0.0001

BOUNDS ON CONDITION NUMBER: 1, 1

STEP 2 VARIABLE GR ENTERED R SQUARE = 0.60530897
C(P) = 198582083.022

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	64.54915924	32.27457962	194.00	0.0001
ERROR	253	42.08920688	0.16636050		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
GT	0.36974998	0.02549207	34.99905142	210.38	0.0001
GR	0.33975007	0.02549207	29.55010782	177.63	0.0001

BOUNDS ON CONDITION NUMBER: 1, 4

STEP 3 VARIABLE PD ENTERED R SQUARE = 0.76052208
C(P) = 120489149.017

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	81.10083173	27.03361058	266.76	0.0001
ERROR	252	25.53753439	0.10133942		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
GT	0.36974998	0.01989616	34.99905142	345.36	0.0001
GR	0.33975007	0.01989616	29.55010782	291.60	0.0001
PD	-0.25427342	0.01989616	16.55167250	163.33	0.0001

BOUNDS ON CONDITION NUMBER: 1, 9

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 4 VARIABLE P ENTERED R SQUARE = 0.88380434
C(P) = 58461697.0699

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	94.24745108	23.56186277	477.29	0.0001
ERROR	251	12.39091504	0.04936620		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
P	0.22661417	0.01388657	13.14661935	266.31	0.0001
GT	0.36974998	0.01388657	34.99905142	708.97	0.0001
GR	0.33975007	0.01388657	29.55010782	598.59	0.0001
PD	-0.25427342	0.01388657	16.55167250	335.28	0.0001

BOUNDS ON CONDITION NUMBER: 1, 16

STEP 5 VARIABLE PFA ENTERED R SQUARE = 0.92892872
C(P) = 35758105.6428

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	99.05944129	19.81188826	653.52	0.0001
ERROR	250	7.57892484	0.03031570		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
P	0.22661417	0.01088213	13.14661935	433.66	0.0001
GT	0.36974998	0.01088213	34.99905142	1154.49	0.0001
GR	0.33975007	0.01088213	29.55010782	974.75	0.0001
PFA	0.13710156	0.01088213	4.81199020	158.73	0.0001
PD	-0.25427342	0.01088213	16.55167250	545.98	0.0001

BOUNDS ON CONDITION NUMBER: 1, 25

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 6 VARIABLE RCS ENTERED R SQUARE = 0.95164172
C(P) = 24330436.8099

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	6	101.48151778	16.91358630	816.68	0.0001
ERROR	249	5.15684834	0.02071023		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
P	0.22661417	0.00899441	13.14661935	634.79	0.0001
GT	0.36974998	0.00899441	34.99905142	1689.94	0.0001
GR	0.33975007	0.00899441	29.55010782	1426.84	0.0001
RCS	0.09726889	0.00899441	2.42207650	116.95	0.0001
PFA	0.13710156	0.00899441	4.81199020	232.35	0.0001
PD	-0.25427342	0.00899441	16.55167250	799.20	0.0001

BOUNDS ON CONDITION NUMBER: 1, 36

STEP 7 VARIABLE N ENTERED R SQUARE = 0.97083450
C(P) = 14673906.3261

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	7	103.52820435	14.78974348	1179.31	0.0001
ERROR	248	3.11016177	0.01254097		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
P	0.22661417	0.00699916	13.14661935	1048.29	0.0001
GT	0.36974998	0.00699916	34.99905142	2790.78	0.0001
GR	0.33975007	0.00699916	29.55010782	2356.28	0.0001
RCS	0.09726889	0.00699916	2.42207650	193.13	0.0001
PFA	0.13710156	0.00699916	4.81199020	383.70	0.0001
PD	-0.25427342	0.00699916	16.55167250	1319.81	0.0001
N	0.08941403	0.00699916	2.04668657	163.20	0.0001

BOUNDS ON CONDITION NUMBER: 1, 49

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 8   VARIABLE F ENTERED   R SQUARE = 0.98466756
C(P) = 7714029.86841

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	8	105.00333942	13.12541743	1982.83	0.0001
ERROR	247	1.63502670	0.00661954		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
P	0.22661417	0.00508504	13.14661935	1986.03	0.0001
GT	0.36974998	0.00508504	34.99905142	5287.23	0.0001
GR	0.33975007	0.00508504	29.55010782	4464.07	0.0001
F	-0.07590946	0.00508504	1.47513507	222.85	0.0001
RCS	0.09726889	0.00508504	2.42207650	365.90	0.0001
PFA	0.13710156	0.00508504	4.81199020	726.94	0.0001
PD	-0.25427342	0.00508504	16.55167250	2500.43	0.0001
N	0.08941403	0.00508504	2.04668657	309.19	0.0001

BOUNDS ON CONDITION NUMBER: 1,   64

STEP 9   VARIABLE NF ENTERED   R SQUARE = 0.99330985
C(P) = 3365801.81334

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	9	105.92493981	11.76943776	4058.28	0.0001
ERROR	246	0.71342631	0.00290011		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
P	0.22661417	0.00336579	13.14661935	4533.15	0.0001
GT	0.36974998	0.00336579	34.99905142	12068.19	0.0001
GR	0.33975007	0.00336579	29.55010782	10189.32	0.0001
F	-0.07590946	0.00336579	1.47513507	508.65	0.0001
NF	-0.06000001	0.00336579	0.92160038	317.78	0.0001
RCS	0.09726889	0.00336579	2.42207650	835.17	0.0001
PFA	0.13710156	0.00336579	4.81199020	1659.25	0.0001
PD	-0.25427342	0.00336579	16.55167250	5707.26	0.0001
N	0.08941403	0.00336579	2.04668657	705.73	0.0001

BOUNDS ON CONDITION NUMBER: 1,   81

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 10 VARIABLE B ENTERED R SQUARE = 0.99602098
C(P) = 2001742.39010

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	10	106.21405044	10.62140504	6132.80	0.0001
ERROR	245	0.42431568	0.00173190		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
P	0.22661417	0.00260101	13.14661935	7590.86	0.0001
GT	0.36974998	0.00260101	34.99905142	20208.46	0.0001
GR	0.33975007	0.00260101	29.55010782	17062.24	0.0001
F	-0.07590946	0.00260101	1.47513507	851.74	0.0001
NF	-0.06000001	0.00260101	0.92160038	532.13	0.0001
B	-0.03360563	0.00260101	0.28911063	166.93	0.0001
RCS	0.09726889	0.00260101	2.42207650	1398.51	0.0001
PFA	0.13710156	0.00260101	4.81199020	2778.44	0.0001
PD	-0.25427342	0.00260101	16.55167250	9556.94	0.0001
N	0.08941403	0.00260101	2.04668657	1181.76	0.0001

BOUNDS ON CONDITION NUMBER: 1, 100

STEP 11 VARIABLE L ENTERED R SQUARE = 0.99818155
C(P) = 914690.726328

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	11	106.44444972	9.67676816	12176.03	0.0001
ERROR	244	0.19391640	0.00079474		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
P	0.22661417	0.00176195	13.14661935	16542.05	0.0001
GT	0.36974998	0.00176195	34.99905142	44038.40	0.0001
GR	0.33975007	0.00176195	29.55010782	37182.14	0.0001
F	-0.07590946	0.00176195	1.47513507	1856.12	0.0001
NF	-0.06000001	0.00176195	0.92160038	1159.63	0.0001
L	-0.02999995	0.00176195	0.23039928	289.91	0.0001
B	-0.03360563	0.00176195	0.28911063	363.78	0.0001
RCS	0.09726889	0.00176195	2.42207650	3047.64	0.0001
PFA	0.13710156	0.00176195	4.81199020	6054.80	0.0001
PD	-0.25427342	0.00176195	16.55167250	20826.54	0.0001
N	0.08941403	0.00176195	2.04668657	2575.29	0.0001

BOUNDS ON CONDITION NUMBER: 1, 121

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 12 VARIABLE PFAPD ENTERED R SQUARE = 0.99954190
C(P) = 230254.406697

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	12	106.58951532	8.88245961	44184.29	0.0001
ERROR	243	0.04885080	0.00020103		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
P	0.22661417	0.00088616	13.14661935	65395.62	0.0001
GT	0.36974998	0.00088616	34.99905142	174096.83	0.0001
GR	0.33975007	0.00088616	29.55010782	146991.99	0.0001
F	-0.07590946	0.00088616	1.47513507	7337.81	0.0001
NF	-0.06000001	0.00088616	0.92160038	4584.34	0.0001
L	-0.02999995	0.00088616	0.23039928	1146.08	0.0001
B	-0.03360563	0.00088616	0.28911063	1438.13	0.0001
RCS	0.09726889	0.00088616	2.42207650	12048.21	0.0001
PFA	0.13710156	0.00088616	4.81199020	23936.43	0.0001
PD	-0.25427342	0.00088616	16.55167250	82333.48	0.0001
N	0.08941403	0.00088616	2.04668657	10180.89	0.0001
PFAPD	-0.02380467	0.00088616	0.14506560	721.60	0.0001

BOUNDS ON CONDITION NUMBER: 1, 144

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 13 VARIABLE PFAN ENTERED R SQUARE = 0.99989256
C(P) = 53827.8229774

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	13	106.62690908	8.20206993	173247.20	0.0001
ERROR	242	0.01145704	0.00004734		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
P	0.22661417	0.00043004	13.14661935	277687.82	0.0001
GT	0.36974998	0.00043004	34.99905142	739263.09	0.0001
GR	0.33975007	0.00043004	29.55010782	624168.46	0.0001
F	-0.07590946	0.00043004	1.47513507	31158.36	0.0001
NF	-0.06000001	0.00043004	0.92160038	19466.39	0.0001
L	-0.02999995	0.00043004	0.23039928	4866.58	0.0001
B	-0.03360563	0.00043004	0.28911063	6106.70	0.0001
RCS	0.09726889	0.00043004	2.42207650	51160.01	0.0001
PFA	0.13710156	0.00043004	4.81199020	101640.66	0.0001
PD	-0.25427342	0.00043004	16.55167250	349610.63	0.0001
N	0.08941403	0.00043004	2.04668657	43230.88	0.0001
PFAPD	-0.02380467	0.00043004	0.14506560	3064.13	0.0001
PFAN	-0.01208592	0.00043004	0.03739376	789.84	0.0001

BOUNDS ON CONDITION NUMBER: 1, 169

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 14 VARIABLE T ENTERED R SQUARE = 0.99995549
C(P) = 22170.4020343

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	14	106.63361924	7.61668709	386700.53	0.0001
ERROR	241	0.00474688	0.00001970		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
P	0.22661417	0.00027738	13.14661935	667456.16	0.0001
GT	0.36974998	0.00027738	34.99905142	999999.99	0.0001
GR	0.33975007	0.00027738	29.55010782	999999.99	0.0001
F	-0.07590946	0.00027738	1.47513507	74892.86	0.0001
NF	-0.06000001	0.00027738	0.92160038	46789.81	0.0001
L	-0.02999995	0.00027738	0.23039928	11697.41	0.0001
B	-0.03360563	0.00027738	0.28911063	14678.20	0.0001
RCS	0.09726889	0.00027738	2.42207650	122969.25	0.0001
T	-0.00511972	0.00027738	0.00671016	340.68	0.0001
PFA	0.13710156	0.00027738	4.81199020	244305.58	0.0001
PD	-0.25427342	0.00027738	16.55167250	840331.30	0.0001
N	0.08941403	0.00027738	2.04668657	103910.63	0.0001
PFAPD	-0.02380467	0.00027738	0.14506560	7365.01	0.0001
PFAN	-0.01208592	0.00027738	0.03739376	1898.49	0.0001

BOUNDS ON CONDITION NUMBER: 1, 196

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 15 VARIABLE PDN ENTERED R SQUARE = 0.99999965
C(P) = -46.99996822

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	15	106.63832861	7.10922191	999999.99	0.0001
ERROR	240	0.00003751	0.00000016		
TOTAL	255	106.63836612			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	5.50176666				
P	0.22661417	0.00002471	13.14661935	999999.99	0.0001
GT	0.36974998	0.00002471	34.99905142	999999.99	0.0001
GR	0.33975007	0.00002471	29.55010782	999999.99	0.0001
F	-0.07590946	0.00002471	1.47513507	999999.99	0.0001
NF	-0.06000001	0.00002471	0.92160038	999999.99	0.0001
L	-0.02999995	0.00002471	0.23039928	999999.99	0.0001
B	-0.03360563	0.00002471	0.28911063	999999.99	0.0001
RCS	0.09726889	0.00002471	2.42207650	999999.99	0.0001
T	-0.00511972	0.00002471	0.00671016	42928.02	0.0001
PFA	0.13710156	0.00002471	4.81199020	999999.99	0.0001
PD	-0.25427342	0.00002471	16.55167250	999999.99	0.0001
N	0.08941403	0.00002471	2.04668657	999999.99	0.0001
PFAPD	-0.02380467	0.00002471	0.14506560	928051.79	0.0001
PFAN	-0.01208592	0.00002471	0.03739376	239225.16	0.0001
PDN	0.00428905	0.00002471	0.00470937	30128.00	0.0001

BOUNDS ON CONDITION NUMBER: 1, 225

NO OTHER VARIABLES MET THE 0.1500 SIGNIFICANCE LEVEL FOR ENTRY INTO THE MODEL.

RADAR RANGE RESIDUALS

SUMMARY OF STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP	VARIABLE ENTERED	VARIABLE REMOVED	NUMBER IN	PARTIAL R**2	MODEL R**2	C(P)
1	GT		1	0.3282	0.3282	3.380E+08
2	GR		2	0.2771	0.6053	1.986E+08
3	PD		3	0.1552	0.7605	1.205E+08
4	P		4	0.1233	0.8838	5.846E+07
5	PFA		5	0.0451	0.9289	3.576E+07
6	RCS		6	0.0227	0.9516	2.433E+07
7	N		7	0.0192	0.9708	1.467E+07
8	F		8	0.0138	0.9847	7.714E+06
9	NF		9	0.0086	0.9933	3.366E+06
10	B		10	0.0027	0.9960	2.002E+06
11	L		11	0.0022	0.9982	9.147E+05
12	PFAPD		12	0.0014	0.9995	2.303E+05
13	PFAN		13	0.0004	0.9999	5.383E+04
14	T		14	0.0001	1.0000	2.217E+04
15	PDN		15	0.0000	1.0000	-4.70E+01

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F	PROB>F
1	GT		124.0905	0.0001
2	GR		177.6269	0.0001
3	PD		163.3291	0.0001
4	P		266.3081	0.0001
5	PFA		158.7293	0.0001
6	RCS		116.9507	0.0001
7	N		163.2000	0.0001
8	F		222.8455	0.0001
9	NF		317.7815	0.0001
10	B		166.9326	0.0001
11	L		289.9055	0.0001
12	PFAPD		721.6042	0.0001
13	PFAN		789.8449	0.0001
14	T		340.6762	0.0001
15	PDN		9999.9999	0.0001

APPENDIX I:

SAS OUTPUT FOR RADAR Y USING DESIGN 3

DEP VARIABLE: RANGE

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	78	44.18525074	0.56647757	999999.990	0.0001
ERROR	177	.00003751395	2.11943E-07		
C TOTAL	255	44.18528826			

ROOT MSE	0.0004603729	R-SQUARE	1.0000
DEP MEAN	4.096915	ADJ R-SQ	1.0000
C.V.	0.01123706		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	4.09691491	.00002877331	99999.999	0.0001
P	1	0.02201137	.00002877331	764.993	0.0001
GT	1	0.18999998	.00002877331	6603.342	0.0001
GR	1	0.11000003	.00002877331	3822.989	0.0001
F	1	-0.0441473	.00002877331	-1534.313	0.0001
NF	1	-0.135	.00002877331	-4691.849	0.0001
L	1	-0.03075	.00002877331	-1068.699	0.0001
B	1	-0.0336057	.00002877331	-1167.946	0.0001
RCS	1	0.0972689	.00002877331	3380.526	0.0001
T	1	-0.00511971	.00002877331	-177.933	0.0001
PFA	1	0.13710156	.00002877331	4764.887	0.0001
PD	1	-0.254273	.00002877331	-8837.129	0.0001
N	1	0.08941402	.00002877331	3107.534	0.0001
PGT	1	-4.68750E-09	.00002877331	-0.000	0.9999
PGR	1	7.81250E-09	.00002877331	0.000	0.9998
PF	1	1.30104E-18	.00002877331	0.000	1.0000
PNF	1	1.01563E-08	.00002877331	0.000	0.9997
PL	1	-3.12500E-09	.00002877331	-0.000	0.9999
PB	1	1.56250E-08	.00002877331	0.001	0.9996
PRCS	1	2.34375E-09	.00002877331	0.000	0.9999
PT	1	6.25000E-09	.00002877331	0.000	0.9998
PPFA	1	1.32812E-08	.00002877331	0.000	0.9996
PPD	1	-9.37500E-09	.00002877331	-0.000	0.9997
PN	1	1.56250E-08	.00002877331	0.001	0.9996
GTGR	1	-1.56250E-08	.00002877331	-0.001	0.9996
GTF	1	-3.43750E-08	.00002877331	-0.001	0.9990
GTNF	1	1.95312E-08	.00002877331	0.001	0.9995
GTL	1	3.12500E-09	.00002877331	0.000	0.9999
GTB	1	-1.09375E-08	.00002877331	-0.000	0.9997
GTRCS	1	8.59375E-09	.00002877331	0.000	0.9998
GTT	1	1.25000E-08	.00002877331	0.000	0.9997
GTPFA	1	-5.46875E-09	.00002877331	-0.000	0.9998

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
GTPD	1	1.25000E-08	.00002877331	0.000	0.9997
GTN	1	-3.12500E-09	.00002877331	-0.000	0.9999
GRF	1	-3.12500E-09	.00002877331	-0.000	0.9999
GRNF	1	3.90625E-09	.00002877331	0.000	0.9999
GRL	1	-3.12500E-09	.00002877331	-0.000	0.9999
GRB	1	-9.97466E-18	.00002877331	-0.000	1.0000
GRRCS	1	8.59375E-09	.00002877331	0.000	0.9998
GRT	1	4.68750E-09	.00002877331	0.000	0.9999
GRPFA	1	7.81250E-10	.00002877331	0.000	1.0000
GRPD	1	9.37500E-09	.00002877331	0.000	0.9997
GRN	1	-4.68750E-09	.00002877331	-0.000	0.9999
FNF	1	-7.03125E-09	.00002877331	-0.000	0.9998
FL	1	2.16840E-18	.00002877331	0.000	1.0000
FB	1	-1.56250E-09	.00002877331	-0.000	1.0000
FRCS	1	-1.32813E-08	.00002877331	-0.000	0.9996
FT	1	3.12500E-09	.00002877331	0.000	0.9999
FPFA	1	-1.79688E-08	.00002877331	-0.001	0.9995
FPD	1	6.25000E-09	.00002877331	0.000	0.9998
FN	1	4.68750E-09	.00002877331	0.000	0.9999
NFL	1	-5.46875E-09	.00002877331	-0.000	0.9998
NFB	1	2.34375E-09	.00002877331	0.000	0.9999
NFRCS	1	-3.12500E-09	.00002877331	-0.000	0.9999
NFT	1	-5.46875E-09	.00002877331	-0.000	0.9998
NFPFA	1	-6.25000E-09	.00002877331	-0.000	0.9998
NFPD	1	2.34375E-09	.00002877331	0.000	0.9999
NFN	1	3.90625E-09	.00002877331	0.000	0.9999
LB	1	2.18750E-08	.00002877331	0.001	0.9994
LRCS	1	7.81250E-10	.00002877331	0.000	1.0000
LT	1	6.25000E-09	.00002877331	0.000	0.9998
LPFA	1	1.01562E-08	.00002877331	0.000	0.9997
LPD	1	2.03125E-08	.00002877331	0.001	0.9994
LN	1	1.71875E-08	.00002877331	0.001	0.9995
BRCS	1	2.10937E-08	.00002877331	0.001	0.9994
BT	1	-1.09375E-08	.00002877331	-0.000	0.9997
BPFA	1	-1.01563E-08	.00002877331	-0.000	0.9997
BPD	1	6.25000E-09	.00002877331	0.000	0.9998
BN	1	2.34375E-08	.00002877331	0.001	0.9994
RCST	1	-7.81250E-10	.00002877331	-0.000	1.0000
RCSPFA	1	-1.56250E-08	.00002877331	-0.001	0.9996
RCSPD	1	-1.01562E-08	.00002877331	-0.000	0.9997
RCSN	1	-1.95313E-08	.00002877331	-0.001	0.9995
TPFA	1	2.34375E-09	.00002877331	0.000	0.9999
TPD	1	-3.43750E-08	.00002877331	-0.001	0.9990
TN	1	3.90313E-18	.00002877331	0.000	1.0000
PFAPD	1	-0.0238047	.00002877331	-827.318	0.0001
PFAN	1	-0.0120859	.00002877331	-420.039	0.0001
PDN	1	0.004289053	.00002877331	149.064	0.0001

RESIDUAL CALCULATIONS

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
1	3.8570	3.8567	3.8E-04
2	4.3128	4.3124	3.8E-04
3	3.8333	3.8329	3.8E-04
4	4.5310	4.5306	3.8E-04
5	4.1420	4.1424	-3.8E-04
6	3.9179	3.9183	-3.8E-04
7	5.0039	5.0042	-3.8E-04
8	4.3473	4.3477	-3.8E-04
9	3.8235	3.8239	-3.8E-04
10	3.6198	3.6202	-3.8E-04
11	4.7058	4.7062	-3.8E-04
12	4.0288	4.0292	-3.8E-04
13	3.9990	3.9986	3.8E-04
14	4.4343	4.4339	3.8E-04
15	3.9547	3.9544	3.8E-04
16	4.6729	4.6726	3.8E-04
17	3.1730	3.1727	3.8E-04
18	3.8912	3.8909	3.8E-04
19	3.9773	3.9769	3.8E-04
20	4.4126	4.4122	3.8E-04
21	4.3641	4.3645	-3.8E-04
22	3.6871	3.6874	-3.8E-04
23	4.2418	4.2422	-3.8E-04
24	4.0381	4.0385	-3.8E-04
25	4.0456	4.0459	-3.8E-04
26	3.3890	3.3894	-3.8E-04
27	3.9437	3.9441	-3.8E-04
28	3.7196	3.7200	-3.8E-04
29	3.3150	3.3146	3.8E-04
30	4.0127	4.0123	3.8E-04
31	4.0987	4.0984	3.8E-04
32	4.5545	4.5541	3.8E-04
33	4.1970	4.1967	3.8E-04
34	3.8498	3.8494	3.8E-04
35	4.4357	4.4353	3.8E-04
36	3.8056	3.8052	3.8E-04
37	3.8226	3.8230	-3.8E-04
38	4.1143	4.1147	-3.8E-04
39	4.2315	4.2319	-3.8E-04
40	4.9966	4.9970	-3.8E-04
41	3.5041	3.5044	-3.8E-04
42	3.8163	3.8166	-3.8E-04
43	3.9335	3.9339	-3.8E-04
44	4.6781	4.6785	-3.8E-04
45	4.3390	4.3386	3.8E-04
46	3.9713	3.9709	3.8E-04
47	4.5572	4.5568	3.8E-04
48	3.9475	3.9471	3.8E-04
49	3.7755	3.7751	3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
50	3.1658	3.1654	3.8E-04
51	4.3173	4.3169	3.8E-04
52	3.9496	3.9492	3.8E-04
53	3.5918	3.5922	-3.8E-04
54	4.3364	4.3368	-3.8E-04
55	3.9224	3.9227	-3.8E-04
56	4.2346	4.2349	-3.8E-04
57	3.2732	3.2736	-3.8E-04
58	4.0383	4.0387	-3.8E-04
59	3.6243	3.6247	-3.8E-04
60	3.9160	3.9164	-3.8E-04
61	3.9174	3.9170	3.8E-04
62	3.2873	3.2869	3.8E-04
63	4.4387	4.4384	3.8E-04
64	4.0915	4.0911	3.8E-04
65	3.6361	3.6365	-3.8E-04
66	4.3807	4.3810	-3.8E-04
67	3.9666	3.9670	-3.8E-04
68	4.2788	4.2792	-3.8E-04
69	4.2598	4.2594	3.8E-04
70	3.6501	3.6497	3.8E-04
71	4.8016	4.8012	3.8E-04
72	4.4339	4.4335	3.8E-04
73	3.9617	3.9613	3.8E-04
74	3.3316	3.3312	3.8E-04
75	4.4830	4.4827	3.8E-04
76	4.1358	4.1354	3.8E-04
77	3.7575	3.7579	-3.8E-04
78	4.5226	4.5230	-3.8E-04
79	4.1086	4.1090	-3.8E-04
80	4.4003	4.4007	-3.8E-04
81	3.3269	3.3273	-3.8E-04
82	3.6186	3.6190	-3.8E-04
83	3.7358	3.7362	-3.8E-04
84	4.5009	4.5013	-3.8E-04
85	4.1413	4.1409	3.8E-04
86	3.7941	3.7937	3.8E-04
87	4.3800	4.3796	3.8E-04
88	3.7499	3.7495	3.8E-04
89	3.8433	3.8429	3.8E-04
90	3.4756	3.4752	3.8E-04
91	4.0615	4.0611	3.8E-04
92	3.4518	3.4514	3.8E-04
93	3.4483	3.4487	-3.8E-04
94	3.7605	3.7609	-3.8E-04
95	3.8778	3.8782	-3.8E-04
96	4.6224	4.6228	-3.8E-04
97	4.2854	4.2858	-3.8E-04
98	3.6084	3.6087	-3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
99	4.1631	4.1635	-3.8E-04
100	3.9594	3.9598	-3.8E-04
101	3.5343	3.5339	3.8E-04
102	4.2525	4.2521	3.8E-04
103	4.3386	4.3382	3.8E-04
104	4.7739	4.7735	3.8E-04
105	3.2363	3.2359	3.8E-04
106	3.9340	3.9336	3.8E-04
107	4.0200	4.0197	3.8E-04
108	4.4758	4.4754	3.8E-04
109	4.4068	4.4072	-3.8E-04
110	3.7503	3.7507	-3.8E-04
111	4.3050	4.3054	-3.8E-04
112	4.0809	4.0813	-3.8E-04
113	3.5233	3.5237	-3.8E-04
114	3.2992	3.2995	-3.8E-04
115	4.3851	4.3855	-3.8E-04
116	3.7286	3.7290	-3.8E-04
117	3.6783	3.6779	3.8E-04
118	4.1341	4.1337	3.8E-04
119	3.6546	3.6542	3.8E-04
120	4.3523	4.3519	3.8E-04
121	3.3803	3.3799	3.8E-04
122	3.8156	3.8152	3.8E-04
123	3.3360	3.3357	3.8E-04
124	4.0542	4.0539	3.8E-04
125	3.6448	3.6452	-3.8E-04
126	3.4411	3.4415	-3.8E-04
127	4.5271	4.5275	-3.8E-04
128	3.8501	3.8504	-3.8E-04
129	3.8876	3.8880	-3.8E-04
130	4.6527	4.6530	-3.8E-04
131	4.2386	4.2390	-3.8E-04
132	4.5304	4.5307	-3.8E-04
133	4.5318	4.5314	3.8E-04
134	3.9016	3.9012	3.8E-04
135	5.0531	5.0527	3.8E-04
136	4.7058	4.7055	3.8E-04
137	4.2132	4.2128	3.8E-04
138	3.6035	3.6032	3.8E-04
139	4.7550	4.7546	3.8E-04
140	4.3873	4.3869	3.8E-04
141	4.0295	4.0299	-3.8E-04
142	4.7741	4.7745	-3.8E-04
143	4.3601	4.3605	-3.8E-04
144	4.6723	4.6727	-3.8E-04
145	3.5784	3.5788	-3.8E-04
146	3.8906	3.8910	-3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
147	4.0078	4.0082	-3.8E-04
148	4.7524	4.7528	-3.8E-04
149	4.4133	4.4129	3.8E-04
150	4.0456	4.0452	3.8E-04
151	4.6315	4.6311	3.8E-04
152	4.0218	4.0215	3.8E-04
153	4.0948	4.0944	3.8E-04
154	3.7475	3.7472	3.8E-04
155	4.3335	4.3331	3.8E-04
156	3.7033	3.7029	3.8E-04
157	3.7203	3.7207	-3.8E-04
158	4.0121	4.0124	-3.8E-04
159	4.1293	4.1297	-3.8E-04
160	4.8944	4.8947	-3.8E-04
161	4.5369	4.5373	-3.8E-04
162	3.8803	3.8807	-3.8E-04
163	4.4351	4.4355	-3.8E-04
164	4.2109	4.2113	-3.8E-04
165	3.8063	3.8059	3.8E-04
166	4.5040	4.5037	3.8E-04
167	4.5901	4.5897	3.8E-04
168	5.0458	5.0455	3.8E-04
169	3.4878	3.4874	3.8E-04
170	4.2060	4.2056	3.8E-04
171	4.2920	4.2916	3.8E-04
172	4.7273	4.7269	3.8E-04
173	4.6788	4.6792	-3.8E-04
174	4.0018	4.0022	-3.8E-04
175	4.5565	4.5569	-3.8E-04
176	4.3529	4.3532	-3.8E-04
177	3.7748	3.7752	-3.8E-04
178	3.5712	3.5715	-3.8E-04
179	4.6571	4.6575	-3.8E-04
180	3.9801	3.9805	-3.8E-04
181	3.9503	3.9499	3.8E-04
182	4.3856	4.3852	3.8E-04
183	3.9061	3.9057	3.8E-04
184	4.6243	4.6239	3.8E-04
185	3.6318	3.6314	3.8E-04
186	4.0875	4.0872	3.8E-04
187	3.6080	3.6076	3.8E-04
188	4.3057	4.3054	3.8E-04
189	3.9168	3.9172	-3.8E-04
190	3.6926	3.6930	-3.8E-04
191	4.7786	4.7790	-3.8E-04
192	4.1220	4.1224	-3.8E-04
193	3.9946	3.9942	3.8E-04
194	4.4299	4.4295	3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
195	3.9504	3.9500	3.8E-04
196	4.6686	4.6682	3.8E-04
197	4.2591	4.2595	-3.8E-04
198	4.0554	4.0558	-3.8E-04
199	5.1414	5.1418	-3.8E-04
200	4.4644	4.4648	-3.8E-04
201	3.9611	3.9614	-3.8E-04
202	3.7369	3.7373	-3.8E-04
203	4.8229	4.8233	-3.8E-04
204	4.1663	4.1667	-3.8E-04
205	4.1161	4.1157	3.8E-04
206	4.5718	4.5715	3.8E-04
207	4.0923	4.0919	3.8E-04
208	4.7900	4.7897	3.8E-04
209	3.3106	3.3102	3.8E-04
210	4.0083	4.0079	3.8E-04
211	4.0944	4.0940	3.8E-04
212	4.5501	4.5497	3.8E-04
213	4.4812	4.4816	-3.8E-04
214	3.8246	3.8250	-3.8E-04
215	4.3794	4.3797	-3.8E-04
216	4.1552	4.1556	-3.8E-04
217	4.1831	4.1835	-3.8E-04
218	3.5061	3.5065	-3.8E-04
219	4.0608	4.0612	-3.8E-04
220	3.8571	3.8575	-3.8E-04
221	3.4321	3.4317	3.8E-04
222	4.1503	4.1499	3.8E-04
223	4.2363	4.2359	3.8E-04
224	4.6716	4.6712	3.8E-04
225	4.3346	4.3342	3.8E-04
226	3.9669	3.9665	3.8E-04
227	4.5528	4.5524	3.8E-04
228	3.9431	3.9427	3.8E-04
229	3.9397	3.9401	-3.8E-04
230	4.2519	4.2523	-3.8E-04
231	4.3691	4.3695	-3.8E-04
232	5.1137	5.1141	-3.8E-04
233	3.6416	3.6420	-3.8E-04
234	3.9333	3.9337	-3.8E-04
235	4.0506	4.0510	-3.8E-04
236	4.8156	4.8160	-3.8E-04
237	4.4561	4.4557	3.8E-04
238	4.1088	4.1085	3.8E-04
239	4.6948	4.6944	3.8E-04
240	4.0646	4.0642	3.8E-04
241	3.9130	3.9127	3.8E-04
242	3.2829	3.2825	3.8E-04

OBS	ACTUAL	PREDICT VALUE	RESIDUAL
243	4.4344	4.4340	3.8E-04
244	4.0871	4.0867	3.8E-04
245	3.7089	3.7093	-3.8E-04
246	4.4739	4.4743	-3.8E-04
247	4.0599	4.0603	-3.8E-04
248	4.3516	4.3520	-3.8E-04
249	3.4108	3.4112	-3.8E-04
250	4.1554	4.1558	-3.8E-04
251	3.7414	3.7418	-3.8E-04
252	4.0536	4.0540	-3.8E-04
253	4.0345	4.0341	3.8E-04
254	3.4248	3.4245	3.8E-04
255	4.5763	4.5759	3.8E-04
256	4.2086	4.2082	3.8E-04

SUM OF RESIDUALS -8.32667E-16
SUM OF SQUARED RESIDUALS .00003751395

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                         RADAR RANGE RESIDUALS
                PLOT OF RESIDUAL*RANGE    SYMBOL USED IS *

            |
    0.0004 +
           |      * ***** **** *************************************      **
           |
           |
           |
           |
    0.0003 +
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    0.0002 +
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           |
    0.0001 +
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R          |
E          |
S   0.0000 +
I          |
D          |
U          |
A          |
L  -0.0001 +
S          |
           |
           |
           |
   -0.0002 +
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           |
   -0.0003 +
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           |
           |        *** ** ***** *************************** *** *** *  *  **
   -0.0004 +
           |
           |
           |
           |
   -0.0005 +
           --+--+--+--+--+--+--+--+--+--+--
            3.0  3.2  3.4  3.6  3.8  4.0  4.2  4.4  4.6  4.8  5.0

                                   RANGE
NOTE:      160 OBS HIDDEN      RADAR RANGE RESIDUALS
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STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

NOTE: SLENTRY AND SLSTAY HAVE BEEN SET TO .15 FOR THE STEPWISE TECHNIQUE.

STEP 1 VARIABLE PD ENTERED R SQUARE = 0.37459691
C(P) = 130381927.172

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	1	16.55167250	16.55167250	152.14	0.0001
ERROR	254	27.63361576	0.10879376		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
PD	-0.25427342	0.02061494	16.55167250	152.14	0.0001

BOUNDS ON CONDITION NUMBER: 1, 1

STEP 2 VARIABLE GT ENTERED R SQUARE = 0.58375245
C(P) = 86777803.6680

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	2	25.79327022	12.89663511	177.41	0.0001
ERROR	253	18.39201804	0.07269572		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
GT	0.18999998	0.01685134	9.24159772	127.13	0.0001
PD	-0.25427342	0.01685134	16.55167250	227.68	0.0001

BOUNDS ON CONDITION NUMBER: 1, 4

STEP 3 VARIABLE PFA ENTERED R SQUARE = 0.69265726
C(P) = 64073654.4794

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	3	30.60526058	10.20175353	189.31	0.0001
ERROR	252	13.58002767	0.05388900		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
GT	0.18999998	0.01450875	9.24159772	171.49	0.0001
PFA	0.13710156	0.01450875	4.81199037	89.29	0.0001
PD	-0.25427342	0.01450875	16.55167250	307.14	0.0001

BOUNDS ON CONDITION NUMBER: 1, 9

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 4 VARIABLE NF ENTERED R SQUARE = 0.79824897
C(P) = 42060209.1734

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	4	35.27086096	8.81771524	248.28	0.0001
ERROR	251	8.91442730	0.03551565		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
GT	0.18999998	0.01177850	9.24159772	260.21	0.0001
NF	-0.13500001	0.01177850	4.66560038	131.37	0.0001
PFA	0.13710156	0.01177850	4.81199037	135.49	0.0001
PD	-0.25427342	0.01177850	16.55167250	466.04	0.0001

BOUNDS ON CONDITION NUMBER: 1, 16

STEP 5 VARIABLE GR ENTERED R SQUARE = 0.86835379
C(P) = 27444966.4767

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	5	38.36846263	7.67369253	329.81	0.0001
ERROR	250	5.81682562	0.02326730		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
GT	0.18999998	0.00953351	9.24159772	397.19	0.0001
GR	0.11000003	0.00953351	3.09760167	133.13	0.0001
NF	-0.13500001	0.00953351	4.66560038	200.52	0.0001
PFA	0.13710156	0.00953351	4.81199037	206.81	0.0001
PD	-0.25427342	0.00953351	16.55167250	711.37	0.0001

BOUNDS ON CONDITION NUMBER: 1, 25

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 6 VARIABLE RCS ENTERED R SQUARE = 0.92317017
C(P) = 16017013.2510

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	6	40.79053999	6.79842333	498.65	0.0001
ERROR	249	3.39474827	0.01363353		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
GT	0.18999998	0.00729767	9.24159772	677.86	0.0001
GR	0.11000003	0.00729767	3.09760167	227.20	0.0001
NF	-0.13500001	0.00729767	4.66560038	342.22	0.0001
RCS	0.09726890	0.00729767	2.42207735	177.66	0.0001
PFA	0.13710156	0.00729767	4.81199037	352.95	0.0001
PD	-0.25427342	0.00729767	16.55167250	1214.04	0.0001

BOUNDS ON CONDITION NUMBER: 1, 36

STEP 7 VARIABLE N ENTERED R SQUARE = 0.96949069
C(P) = 6360249.40807

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	7	42.83722580	6.11960369	1125.81	0.0001
ERROR	248	1.34806245	0.00543574		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
GT	0.18999998	0.00460797	9.24159772	1700.16	0.0001
GR	0.11000003	0.00460797	3.09760167	569.86	0.0001
NF	-0.13500001	0.00460797	4.66560038	858.32	0.0001
RCS	0.09726890	0.00460797	2.42207735	445.58	0.0001
PFA	0.13710156	0.00460797	4.81199037	885.25	0.0001
PD	-0.25427342	0.00460797	16.55167250	3044.97	0.0001
N	0.08941402	0.00460797	2.04668582	376.52	0.0001

BOUNDS ON CONDITION NUMBER: 1, 49

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 8 VARIABLE F ENTERED R SQUARE = 0.98078266
C(P) = 4006135.73913

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	8	43.33616460	5.41702058	1575.75	0.0001
ERROR	247	0.84912365	0.00343775		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
GT	0.18999998	0.00366452	9.24159772	2688.27	0.0001
GR	0.11000003	0.00366452	3.09760167	901.06	0.0001
F	-0.04414725	0.00366452	0.49893880	145.14	0.0001
NF	-0.13500001	0.00366452	4.66560038	1357.17	0.0001
RCS	0.09726890	0.00366452	2.42207735	704.55	0.0001
PFA	0.13710156	0.00366452	4.81199037	1399.75	0.0001
PD	-0.25427342	0.00366452	16.55167250	4814.69	0.0001
N	0.08941402	0.00366452	2.04668582	595.36	0.0001

BOUNDS ON CONDITION NUMBER: 1, 64

STEP 9 VARIABLE B ENTERED R SQUARE = 0.98732582
C(P) = 2642039.87056

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	9	43.62527586	4.84725287	2129.28	0.0001
ERROR	246	0.56001239	0.00227647		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
GT	0.18999998	0.00298203	9.24159772	4059.61	0.0001
GR	0.11000003	0.00298203	3.09760167	1360.70	0.0001
F	-0.04414725	0.00298203	0.49893880	219.17	0.0001
NF	-0.13500001	0.00298203	4.66560038	2049.49	0.0001
B	-0.03360567	0.00298203	0.28911126	127.00	0.0001
RCS	0.09726890	0.00298203	2.42207735	1063.96	0.0001
PFA	0.13710156	0.00298203	4.81199037	2113.79	0.0001
PD	-0.25427342	0.00298203	16.55167250	7270.75	0.0001
N	0.08941402	0.00298203	2.04668582	899.06	0.0001

BOUNDS ON CONDITION NUMBER: 1, 81

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 10   VARIABLE L ENTERED   R SQUARE = 0.99280420
C(P) = 1499924.87546

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	10	43.86733979	4.38673398	3380.26	0.0001
ERROR	245	0.31794847	0.00129775		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
GT	0.18999998	0.00225152	9.24159772	7121.25	0.0001
GR	0.11000003	0.00225152	3.09760167	2386.90	0.0001
F	-0.04414725	0.00225152	0.49893880	384.46	0.0001
NF	-0.13500001	0.00225152	4.66560038	3595.15	0.0001
L	-0.03075000	0.00225152	0.24206393	186.53	0.0001
B	-0.03360567	0.00225152	0.28911126	222.78	0.0001
RCS	0.09726890	0.00225152	2.42207735	1866.37	0.0001
PFA	0.13710156	0.00225152	4.81199037	3707.95	0.0001
PD	-0.25427342	0.00225152	16.55167250	12754.14	0.0001
N	0.08941402	0.00225152	2.04668582	1577.10	0.0001

BOUNDS ON CONDITION NUMBER: 1,   100

STEP 11   VARIABLE PFAPD ENTERED   R SQUARE = 0.99608732
C(P) = 815471.674705

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	11	44.01240541	4.00112776	5647.03	0.0001
ERROR	244	0.17288284	0.00070854		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
GT	0.18999998	0.00166365	9.24159772	13043.23	0.0001
GR	0.11000003	0.00166365	3.09760167	4371.83	0.0001
F	-0.04414725	0.00166365	0.49893880	704.18	0.0001
NF	-0.13500001	0.00166365	4.66560038	6584.84	0.0001
L	-0.03075000	0.00166365	0.24206393	341.64	0.0001
B	-0.03360567	0.00166365	0.28911126	408.04	0.0001
RCS	0.09726890	0.00166365	2.42207735	3418.42	0.0001
PFA	0.13710156	0.00166365	4.81199037	6791.45	0.0001
PD	-0.25427342	0.00166365	16.55167250	23360.38	0.0001
N	0.08941402	0.00166365	2.04668582	2888.61	0.0001
PFAPD	-0.02380468	0.00166365	0.14506562	204.74	0.0001

BOUNDS ON CONDITION NUMBER: 1,   121

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 12 VARIABLE P ENTERED R SQUARE = 0.99889441
C(P) = 230259.756018

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	12	44.13643752	3.67803646	18295.79	0.0001
ERROR	243	0.04885074	0.00020103		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
P	0.02201137	0.00088616	0.12403211	616.98	0.0001
GT	0.18999998	0.00088616	9.24159772	45970.82	0.0001
GR	0.11000003	0.00088616	3.09760167	15408.51	0.0001
F	-0.04414725	0.00088616	0.49893880	2481.89	0.0001
NF	-0.13500001	0.00088616	4.66560038	23208.27	0.0001
L	-0.03075000	0.00088616	0.24206393	1204.11	0.0001
B	-0.03360567	0.00088616	0.28911126	1438.14	0.0001
RCS	0.09726890	0.00088616	2.42207735	12048.23	0.0001
PFA	0.13710156	0.00088616	4.81199037	23936.46	0.0001
PD	-0.25427342	0.00088616	16.55167250	82333.59	0.0001
N	0.08941402	0.00088616	2.04668582	10180.90	0.0001
PFAPD	-0.02380468	0.00088616	0.14506562	?1.61	0.0001

BOUNDS ON CONDITION NUMBER: 1, 144

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 13 VARIABLE PFAN ENTERED R SQUARE = 0.99974071
C(P) = 53828.9580394

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	13	44.17383125	3.39798702	71773.81	0.0001
ERROR	242	0.01145700	0.00004734		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
P	0.02201137	0.00043004	0.12403211	2619.86	0.0001
GT	0.18999998	0.00043004	9.24159772	195205.18	0.0001
GR	0.11000003	0.00043004	3.09760167	65428.94	0.0001
F	-0.04414725	0.00043004	0.49893880	10538.81	0.0001
NF	-0.13500001	0.00043004	4.66560038	98548.91	0.0001
L	-0.03075000	0.00043004	0.24206393	5112.98	0.0001
B	-0.03360567	0.00043004	0.28911126	6106.74	0.0001
RCS	0.09726890	0.00043004	2.42207735	51160.21	0.0001
PFA	0.13710156	0.00043004	4.81199037	101641.02	0.0001
PD	-0.25427342	0.00043004	16.55167250	349611.87	0.0001
N	0.08941402	0.00043004	2.04668582	43231.02	0.0001
PFAPD	-0.02380468	0.00043004	0.14506562	3064.14	0.0001
PFAN	-0.01208591	0.00043004	0.03739373	789.85	0.0001

BOUNDS ON CONDITION NUMBER: 1, 169

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 14 VARIABLE T ENTERED R SQUARE = 0.99989257
C(P) = 22170.9633093

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	14	44.18054137	3.15575296	160218.04	0.0001
ERROR	241	0.00474688	0.00001970		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
P	0.02201137	0.00027738	0.12403211	6297.13	0.0001
GT	0.18999998	0.00027738	9.24159772	469197.28	0.0001
GR	0.11000003	0.00027738	3.09760167	157265.69	0.0001
F	-0.04414725	0.00027738	0.49893880	25331.20	0.0001
NF	-0.13500001	0.00027738	4.66560038	236873.22	0.0001
L	-0.03075000	0.00027738	0.24206393	12289.62	0.0001
B	-0.03360567	0.00027738	0.28911126	14678.22	0.0001
RCS	0.09726890	0.00027738	2.42207735	122969.22	0.0001
T	-0.00511971	0.00027738	0.00671012	340.67	0.0001
PFA	0.13710156	0.00027738	4.81199037	244305.46	0.0001
PD	-0.25427342	0.00027738	16.55167250	840330.85	0.0001
N	0.08941402	0.00027738	2.04668582	103910.54	0.0001
PFAPD	-0.02380468	0.00027738	0.14506562	7365.00	0.0001
PFAN	-0.01208591	0.00027738	0.03739373	1898.49	0.0001

BOUNDS ON CONDITION NUMBER: 1, 196

RADAR RANGE RESIDUALS

STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP 15 VARIABLE PDN ENTERED R SQUARE = 0.99999915
C(P) = -46.99998931

	DF	SUM OF SQUARES	MEAN SQUARE	F	PROB>F
REGRESSION	15	44.18525074	2.94568338	999999.99	0.0001
ERROR	240	0.00003751	0.00000016		
TOTAL	255	44.18528826			

	B VALUE	STD ERROR	TYPE II SS	F	PROB>F
INTERCEPT	4.09691491				
P	0.02201137	0.00002471	0.12403211	793510.35	0.0001
GT	0.18999998	0.00002471	9.24159772	999999.99	0.0001
GR	0.11000003	0.00002471	3.09760167	999999.99	0.0001
F	-0.04414725	0.00002471	0.49893880	999999.99	0.0001
NF	-0.13500001	0.00002471	4.66560038	999999.99	0.0001
L	-0.03075000	0.00002471	0.24206393	999999.99	0.0001
B	-0.03360567	0.00002471	0.28911126	999999.99	0.0001
RCS	0.09726890	0.00002471	2.42207735	999999.99	0.0001
T	-0.00511971	0.00002471	0.00671012	42928.80	0.0001
PFA	0.13710156	0.00002471	4.81199037	999999.99	0.0001
PD	-0.25427342	0.00002471	16.55167250	999999.99	0.0001
N	0.08941402	0.00002471	2.04668582	999999.99	0.0001
PFAPD	-0.02380468	0.00002471	0.14506562	928074.79	0.0001
PFAN	-0.01208591	0.00002471	0.03739373	239230.90	0.0001
PDN	0.00428905	0.00002471	0.00470937	30128.76	0.0001

BOUNDS ON CONDITION NUMBER: 1, 225

NO OTHER VARIABLES MET THE 0.1500 SIGNIFICANCE LEVEL FOR ENTRY INTO THE MODEL.

RADAR RANGE RESIDUALS

SUMMARY OF STEPWISE REGRESSION PROCEDURE FOR DEPENDENT VARIABLE RANGE

STEP	VARIABLE ENTERED	VARIABLE REMOVED	NUMBER IN	PARTIAL R**2	MODEL R**2	C(P)
1	PD		1	0.3746	0.3746	1.304E+08
2	GT		2	0.2092	0.5838	8.678E+07
3	PFA		3	0.1089	0.6927	6.407E+07
4	NF		4	0.1056	0.7982	4.206E+07
5	GR		5	0.0701	0.8684	2.744E+07
6	RCS		6	0.0548	0.9232	1.602E+07
7	N		7	0.0463	0.9695	6.360E+06
8	F		8	0.0113	0.9808	4.006E+06
9	B		9	0.0065	0.9873	2.642E+06
10	L		10	0.0055	0.9928	1.500E+06
11	PFAPD		11	0.0033	0.9961	8.155E+05
12	P		12	0.0028	0.9989	2.303E+05
13	PFAN		13	0.0008	0.9997	5.383E+04
14	T		14	0.0002	0.9999	2.217E+04
15	PDN		15	0.0001	1.0000	-4.70E+01

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F	PROB>F
1	PD		152.1381	0.0001
2	GT		127.1271	0.0001
3	PFA		89.2945	0.0001
4	NF		131.3675	0.0001
5	GR		133.1311	0.0001
6	RCS		177.6560	0.0001
7	N		376.5242	0.0001
8	F		145.1354	0.0001
9	B		126.9996	0.0001
10	L		186.5260	0.0001
11	PFAPD		204.7399	0.0001
12	P		616.9775	0.0001
13	PFAN		789.8472	0.0001
14	T		340.6738	0.0001
15	PDN		9999.9999	0.0001

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Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE

3. DISTRIBUTION / AVAILABILITY OF REPORT
Approved for public release; distribution unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
AFIT/GOR/ENS/88D-23

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
School of Engineering

6b. OFFICE SYMBOL *(If applicable)*
AFIT/ENS

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS *(City, State, and ZIP Code)*
Air Force Institute of Technology (AU)
Wright-Patterson AFB, Ohio 45433-6583

7b. ADDRESS *(City, State, and ZIP Code)*

8a. NAME OF FUNDING / SPONSORING ORGANIZATION
ESC/AFEWC

8b. OFFICE SYMBOL *(If applicable)*
ESA

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS *(City, State, and ZIP Code)*
AFEWC/ESA
Kelly AFB, Texas 78243-5000

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO	WORK UNIT ACCESSION NO.

11. TITLE *(Include Security Classification)*
RESPONSE SURFACE METHODOLOGY APPLIED TO THE RADAR RANGE EQUATION (UNCLASSIFIED)

12. PERSONAL AUTHOR(S)
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13a. TYPE OF REPORT
MS Thesis

13b. TIME COVERED
FROM ________ TO ______

14. DATE OF REPORT *(Year, Month, Day)*
1988 December

15. PAGE COUNT
143

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP
12	03	
17	09	

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
Response Surface Methodology, Linear Regression Analysis, Radar Range Equation, EWIR Database, Continuous Wave Radar

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

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The purpose of this thesis is to analyze the Electronic Warfare Integrated Reprogramming (EWIR) database elements. The integration time for continuous wave radars is illustrated. The effects of the confidence factors on data within the database is analyzed. These confidence factors affect certain parameters more than others and they also affect the radar range. Response surface methodology is used to identify the significant effects on the radar range equation, using EWIR database parameters. Linear equations are created for several radars and are compared to the actual ranges.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT
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21. ABSTRACT SECURITY CLASSIFICATION
UNCLASSIFIED

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22c. OFFICE SYMBOL
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DD Form 1473, JUN 86 *Previous editions are obsolete.*

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